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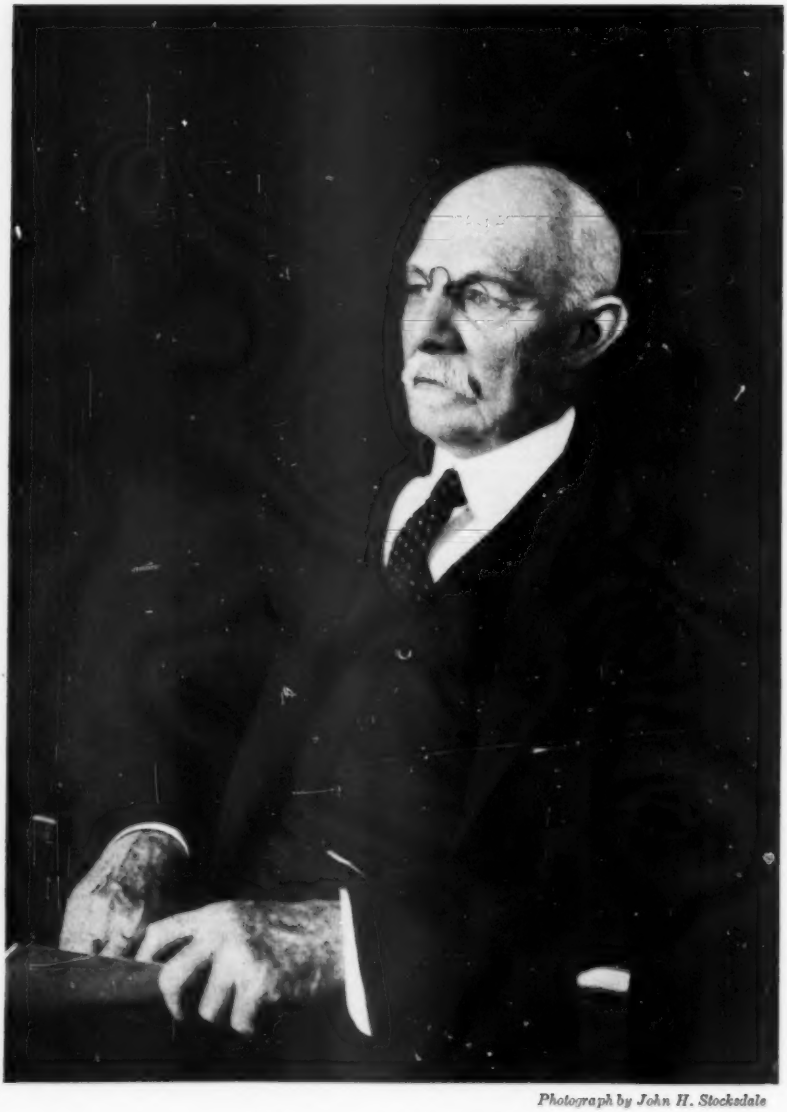

Photograph by John H. Stockdale

Dr. William S. Halsted, 1922

Memorial Meeting for Dr. William Stewart Halsted, Late Professor of Surgery in The Johns Hopkins Medical School

Held at Homewood, Sunday Afternoon, December 16, 1923

PRESIDENT FRANK J. GOODNOW, PRESIDING

Ladies and Gentlemen:

We have come together this afternoon to honor the memory of our revered colleague and friend Dr. William Stewart Halsted, who during his life contributed so much both to the subject to which he had devoted himself and to the prestige of the institution with which he was connected.

It is to others more competent than I that we must look for an appreciation of the great services which he rendered. I can only say a few words about his loyalty to and love for The Johns Hopkins University which suffers in his death irreparable loss. It is only characteristic of the man that when he died he not only left us the lustre of a name that will always be honored by Hopkins men but as well made the University his residuary legatee in order to enable it more adequately to carry on the work which he had so auspiciously begun, namely, research in surgery.

We had hoped to have with us today Dr. John C. Da Costa, of Philadelphia, who, however, writes us that he has been prevented from coming by serious illness.

We shall have the privilege of hearing from Dr. Matas, a distinguished surgeon from New Orleans, Dr. Finney of our own Medical Faculty and Dr. Welch one of Dr. Halsted's intimate and lifelong friends.

BULLETIN OF THE JOHNS HOPKINS HOSPITAL, VOL. XXXVI, NO. 1

In Memoriam—William Stewart Halsted

An Appreciation

By Rudolph Matas

Professor of Surgery, Tulane University, New Orleans, Louisiana

WHEN I accepted the gracious invitation of President Goodnow to join the friends of Professor Halsted in a public tribute to his memory, I did so gladly and gratefully. Indulging no vain illusion that anything which I might say could add weight to such merits and virtues as have exalted his acknowledged rank, nor that, by any grace of speech, I might place further emphasis upon the eloquence of those far abler to express the sentiments of affection and admiration which Dr. Halsted inspired, I was conscious, nevertheless, that, although one of the least worthy among his friends and admirers, none other would come to this gathering whose heart overflowed with greater gratitude and appreciation.

Few have been permitted to enjoy such immeasurable good as came to me through him. Not only profiting by his sympathy, counsel and experience in a way far exceeding the benefits that have accrued to many of his nearer colleagues and associates—benefits that have contributed in no small measure to my professional enlightenment and improvement—I also owe him a debt which is far more direct and personal, a debt that cannot be estimated nor expressed in mere words. In his lifetime, he had rendered me a service in which his surgical skill and kindness had united to relieve me of a heavy burden; thereby making my travel through life much lighter, and introducing contentment and confidence where previously there had been only uncertainty, danger and doubt. It is, therefore, as a debtor, in more than one sense, that I am here, seeking to repay that which I can never hope to return, even in small installments.

Though not of Dr. Halsted's official family, and with no claim to recognition as one of his pupils and associates, I feel that, through the ties of strong affection that bound me to him, I am entitled to wear the badge of mourning which, if not outwardly displayed, is well wrapped around my heart.

You will pardon this allusion to my personal relations with Dr. Halsted. It has no other purpose than to disclaim any pretense to exploit my friendship for him or the warm feeling that, I have every reason to believe, he entertained for me; nor any motives

that might redound to my own advantage; nor that I might assume the privilege of acting as his biographer on this occasion. Even though this function were becoming in me, this is not the time nor place in which to exercise it. That must be the sacred part of those who dwelt in close and intimate association with Dr. Halsted; who living with him in daily communion, participating in the routine activities of his life, are privileged to write a biography that will do justice to his labors and to his personality. This task has been in some measure accomplished in those appreciative notices which have recently appeared over the signatures of two of his most eminent associates and co-workers, Drs. Cushing and Finney. These two admirable sketches suffice to acquaint those who did not know Dr. Halsted personally with the outstanding facts of his life, his antecedents and personal characteristics; but to an audience like this, composed largely, if not wholly of Dr. Halsted's friends, assembled within the walls of the institution which still resounds with the familiar echoes of his voice and retains much of the warmth of his loved presence—a rehearsal of such well known facts would be like bringing coals to Newcastle—a superfluous undertaking. I shall, therefore, dispense with purely biographic details which in the main I should have to borrow from others more competent to speak, and I will confine myself to a simple appreciation of his life from the viewpoint of one, who, looking at him from a distance, kept in close touch with his work and felt a deep interest in his professional achievements; who felt for him that warm sympathy which is engendered by a veneration akin to that of the pupil for a beloved master; who felt for him all the loyalty and sincerity of a grateful friendship, and all the congeniality which is born of a communion of ideas and mutual interests in a common field of endeavor.

What I shall have to say, at this moment, is largely prompted by the very exuberance of my affection, by the very joy of speaking of him, and out of the fullness of my admiration.

We know enough to assert his greatness without fear of exaggeration, but it is our successors, and the generations that will follow them, who, in the light of history, will assign to him its full and just measure.

* * *

My interest in Professor Halsted began early in my professional career, when the distinctive qualities of his work had begun to attract attention,—foreshadowing his future eminence as one of the leading lights of surgery in this country. It was late in the eighties, when all eyes were turned towards Baltimore, where the directing genius of Dr. John Shaw Billings had planned and laid the foundation for a medical school destined to revolutionize all previous concepts and standards of hospital organization in America. As Director of the Surgeon General's Library in Washington, Dr. Billings' kindness and encouragement to the young men who frequented the Library is gratefully remembered by all who, like myself, were the recipients of his favor while he was the inspiring and generous custodian of that priceless repository of medical lore. It was through Dr. Billings that it was

my good fortune to attend the opening exercises which inaugurated the Johns Hopkins Hospital in 1889, and it was from that eventful year that, chiefly through my devotion to Dr. Billings and my interest in the success of his enterprises, there developed a sympathy and affection for this institution which has grown stronger ever since.

I cannot refer to those early days without rubbing my eyes to visualize more clearly the great length of the path over which Medicine has traveled in that short span of scarcely four decades which have elapsed since the vigorous seed planted by the generous Hopkins has grown into the stately tree that is giving us shelter today. But, we cannot reflect upon the stupendous progress accomplished during this period in the history of American medical institutions, without evoking the image of that group of supermen—the great quadrumvirate, Welch, Osler, Halsted, Kelly, and their associates—who, by virtue of their example and achievements in this institution have exercised the most profound and salutary influence in directing and stimulating the medical profession of this country to the attainment of its present high aims and ideals.

It was not until 1903, just twenty years ago, that I first came to know Dr. Halsted in the light of his personal attributes as a man. Up to that time, I had become familiar only with his scientific attitude of mind, and, like every other surgeon in the country who is interested in the progress of his profession, I had been impressed with the importance of his researches, the originality of his ideas, and the thoroughness of his practice. We had met casually at the meetings of the American Surgical Association. In 1897, he had made a fleeting visit to New Orleans, in attendance upon the meeting of our national organization, where, contrary to his custom, he had reluctantly given a remarkable demonstration of his operation for hernia, at our Charity Hospital; but his reserve and caution in making new acquaintances, his seeming formality, always well concealed by the most perfect urbanity, made him rather difficult of approach and kept at a distance men who, fully aware of his great worth and of the prestige of his well earned national reputation, were eager to meet him but made no advances, owing to the impression that Dr. Halsted would not be overresponsive to their attentions.

In 1898 and 1899, in consequence of my interest in regional and local anesthesia, I came into a closer knowledge of the pioneer labors of Dr. Halsted, which gave him the rightful claim to the discovery of neuroregional anesthesia—the so-called "conduction anesthesia" of the German writers—better known with us as "nerve blocking" which, thanks to his initiative and personal experiments upon himself, led to the extraordinary developments of this mode of abolishing pain that we have all witnessed with amazement in the last few years. Not only did he clearly and unequivocally demonstrate for the first time that the principle of nerve blocking could be utilized to obtain the anesthesia of the peripheral nerves for surgical purposes—a discovery promptly utilized in dental and oral practice—but he went a step further

and demonstrated that the blocking of the spinal cord with anesthetic drugs could be made subservient to this general principle.

From his early experiments and researches, a general law was formulated, which could well be named after him, "Halsted's Law" namely, that the infiltration of a sectional area of sensory nerve trunk or path, with an analgesic substance, was equal to the anesthesia of its peripheral distribution. This, in essence, is the very foundation of all the present and most useful methods of regional anesthesia.

He also anticipated and even went a step further than Schleich, who is credited as the originator of the principle that plain isotonic saline solutions, when massively infiltrated into the tissues so as to produce a tense local dropsy, were capable of producing local anesthesia, even for surgical purposes; thereby demonstrating that extremely dilute solutions of cocaine and other dangerous drugs could be used effectively in almost infinitesimal dilutions, thus relieving them of their toxic qualities.

It is interesting to relate, as told by Cushing, that fifteen years later when Cushing rediscovered the principle of nerve blocking and applied it successfully in operations on hernia, publishing his well known paper on the subject, he was utterly unaware that his chief had ever made studies on cocaine of any sort—so reticent was Dr. Halsted about this matter and so little did questions of priority interest him.[1]

[1] It is only quite recently, on April 1, 1922, barely six months before Dr. Halsted's death, that the fundamental importance and significance of his great discoveries in local and regional analgesia were duly recognized by the American National Dental Association. After the painstaking investigation of a committee headed by the distinguished dentist, Dr. C. Edmund Kells, of New Orleans, this representative body presented him with the beautifully designed gold medal and gave him full credit as the originator of the method of neuroregional anesthesia which has proven of such incalculable service in oral and dental surgery.

The following extracts from a letter addressed by Dr. Halsted to the writer, on April 3, 1922, the day following the brilliant and enthusiastic ovation tendered him by the National and Maryland Dental Associations are quoted to show how thoroughly human Dr. Halsted was and how sensitively he reacted to this spontaneous and most genuine, though belated, tribute to his great discovery.

He wrote: "The Celebration, as Dr. Kells will tell you, was a remarkable success. I am so thankful to have lived to take part in it. Not a wink of sleep did I get during the night of Saturday. I was too exhilarated for repose. Once before in my life, I was kept awake by great happiness; this was the night that I passed successfully the examination for Bellevue Hospital in 1876. Here it was in contemplation of the future, now in reflection upon the good fortune that led to our friendship. The reaction from this great joy seems to be setting in to-night and my happiness is tinged with regret for the lost opportunities, for the time wasted from loss of health, etc."

In his touching allusion to "our friendship" with special reference to this occasion he had in mind the fact that I had been instrumental, without his knowledge, in securing complete and indisputable evidence of his right to priority in the discovery of regional anesthesia "nerve blocking"—as applied especially to dental and oral surgery, and had established his historic right to recognition by the Dental Associations in papers published long before I had known him personally.

While local and regional analgesia had been one of his great passions, Dr. Halsted

A similar illustration of his indifference to mere claims of priority was repeated only a year ago, 1922, when, in the course of a discussion at the American Surgical Association of a paper by Dr. Edward Klopp of Philadelphia on "Refusion or Reinfusion of Blood in Hemorrhage" it came to light that Dr. Halsted had frequently practised the procedure thirty years previously and had saved a number of lives by its application while acting as surgeon at the old Chambers Street Hospital in New York. Credit had been given Johann Thiess of Leipzig, as the originator of this method of reinfusion or auto-transfusion. This surgeon had published his experience in 1914 when he had applied it for the relief of exsanguinated patients in ruptured extrauterine pregnancy; but Dr. Halsted had clearly antedated him by at least thirty-one years, as will be seen by anyone consulting the files of the *Annals of Surgery* (vol. ix, pp. 7–21, 1884) and the *Proceedings of the New York Surgical Society* of November 13, 1883 (*New York Medical Journal*, 1883, vol. xxxviii, pp. 625–629), in which are described his experiences and clinical applications of the principle of blood "refusion" (as he termed it) in the treatment of illuminating gas poisoning. After copious blood-letting, the blood of the patient was collected, defibrinated and thereby sufficiently aerated to deprive it of its toxic properties. It was then filtered and reinfused into the radial artery of the same patient, thus administering an arterial centripetal infusion. The results obtained by this procedure—suggested to Dr. Halsted by reading Hermann's Physiology and Hütter's advocacy of arterial transfusion in preference to the venous route—were remarkable. Patients, who were comatose, would, after bleeding, promptly become conscious and even quite rational, and upon the reinfusion of the defibrinated and detoxicated blood would recover still further. The technique of refusion in hemorrhage, as practised at the

did not overlook the progress of general anesthesia. In this also he was in the van of progress; for on February 17, 1910, while participating in a discussion at the New York Academy of Medicine, on Meltzer and Auer's method of intratracheal ventilation in its application to intrathoracic operations for purposes of artificial respiration and anesthesia, he referred to his own experiments, at Hopkins, with differential pressure in pulmonary and intrapleural operations on the lower animals, and incidentally gave an account of his experience with a mixture of nitrous oxid, carbon dioxid and oxygen, which he has been using very successfully for one year in his clinic. In closing his remarks he said that before he had used these gases, he had not realized how detrimental the use of ether was in comparison. (*Med. Record*, March 19, 1910, p. 511.) Here we see him as a pioneer in a new field, trying and investigating a combination of anesthetic gases at a time when gas-oxygen sequence and gas-oxygen mixture for prolonged surgical operations was practically unknown, and ether was still the universal anesthetic in surgery.

In connection with the Meltzer-Auer method of intratracheal ventilation for artificial respiration, the following passage from a personal letter addressed to me by Professor Halsted on July 10, 1921, is interesting. "I wish I could have heard your paper on pneumothorax. You will, I trust, favor me with a reprint. Meltzer and Auer anticipated me in the publication of the insufflation method. Gatch, my assistant, and I had been working for some time along the same lines, but not knowing of Meltzer's work, were too deliberate. Meltzer was such a true friend to me that I would not in any event, have tried to anticipate him."

present time, is different in many respects, but remains essentially the same in principle as that first applied by Halsted, forty-three years ago. And, yet, as in the case of the discovery of neuroregional anesthesia, it would have remained buried in oblivion, so far as Dr. Halsted himself was concerned.[2]

* * *

It was in the fall of 1903, a little over twenty years ago, fourteen years after I had known Professor Halsted as a great soulful surgeon, that I came to know him for the first time by personal contact and under circumstances which revealed the still greater qualities of his heart. As I was convalescing in his home, I learned to love the sound of his cautious footsteps as he approached my room late at night, to assure himself of my comfort and to inquire with parental solicitude into the events of the day. He would sit by my bedside and, relaxing after the arduous work of the day, indulge me with his commentaries on many of the questions and problems of the day in which we were mutually interested. He often reverted to his post-graduate days in Leipzig, Vienna, Berne, which had been destined to exercise such a profound influence upon his career as a teacher and operator. That he was held in the highest esteem in Germany is evident from the eagerness with which his publications were sought by the leading German surgical journals and societies, and from the fact that his clinic at Johns Hopkins Hospital was the only American institution included in the list of the great clinics that enrich the pages of that leading organ of German surgical thought, Bruns' *Beiträge zur Chirurgie*. He had already been elected an honorary fellow of the Royal College of Surgeons of England, and of the Royal College of Surgeons of Edinburgh, of the Deutsche Gesselschaft für Chirurgie, and of that exclusive body, the Société de Chirurgie de Paris—all very highly prized and coveted honors, which he duly appreciated but to which he only referred in the most modest unpretentious way, and merely in connection with interesting episodes or incidents that had occurred in the course of his visits to foreign capitals. His critical comments on surgi-

[2] Two remarkable incidents which occurred early in Dr. Halsted's career are recalled by the reference to his original method of blood "refusion." The first is the saving of his sister's life when exsanguinated, seemingly moribund from the effects of postpartum hemorrhage. He arrived at the critical moment, arrested the hemorrhage which had resisted the efforts of the attending obstetrician and immediately revived her by transfusing her *with his own blood*. This occurred in 1881, six years after his graduation in medicine. A year later he was summoned in haste to his mother's bedside at Albany and arrived in time to operate at 2:00 a.m., and save her life by draining an empyema of the gall-bladder which was about to rupture, and extracting seven gall-stones. In both instances the ablest surgeons had been in attendance. This was in 1882, and is one of the earliest deliberately planned operations for gall-stones in this country. These remarkable incidents will no doubt receive proper appreciation in his biography, as they reveal not only Dr. Halsted's resolute character, his courage, clear vision and strong convictions in matters which to most men of his time were still hazy and practically intangible. They also show that in matters of surgical knowledge and judgment he was way ahead of his time.

cal institutions and leaders abroad, as compared with our own, were most illuminating.

It is quite evident that all his honors had come to him spontaneously, and solely through his own merit. Never by self-seeking, nor by the employment of subtle diplomatic agencies, so often the resort of men of lesser worth.

He often referred to the early experiences of his career, when he had returned from Europe full of enthusiasm, fired with a laudable ambition to improve his opportunities for the expansion of his active mind in the promising field that was assured him in New York. Throughout these friendly chats, he referred to his achievements in New York only as reminiscences, laying no stress upon the prime rôle which he had played in these epochal discoveries. In connection with the discovery of neuroregional anesthesia, he casually referred to a major operation, which he had performed in the winter of 1884–1885 under regional anesthesia, and in which he had freed the cords and nerves of the brachial plexus by blocking its roots in the neck with cocaine solution. As illustrating his enthusiasm and enterprise in testing all new methods that appealed to his investigating mind, this operation on the plexus (which I do not believe is now known to many) is interesting, as it was performed in a large tent which he had built and furnished at his own expense on the grounds of Bellevue Hospital, having found it impossible to carry out antiseptic precautions in the general amphitheatre of Bellevue, where, he said, "Numerous antagonistic anti-Listerian surgeons dominated and predominated."

His constant and affectionate references to the ability and skill of his younger assistants, whose accomplishments he often extolled above his own, impressed one as striking evidence of his wonderful generosity and liberality.

I cannot recall the days passed at Dr. Halsted's home on Eutaw Place, without investing him with all the attributes of a knight of the profession, a pure and high-minded devotee of his art, the modernized replica of such an one as Guy de Chauliac described nearly six centuries ago:

> Bold in those things that are safe, or that he can safeguard by his own judgment and experience; fearful in those that are dangerous; avoiding all evil methods and practices; tender to the sick, honorable to the men of his profession; truthful, wise in his predictions; chaste, sober, pitiful, merciful, not covetous nor extortionate.

Dr. Halsted's gentleness and kindness, his great concern for suffering, his minute precautions against the unnecessary spilling or waste of blood, his watchfulness and anxiety about the fate of his patients, afford one of the most touching and beautiful examples of the humanity and the humane qualities of the real surgeon. There are many still who would interpret a calm and unemotional exterior as an evidence of disregard of suffering or indifference to human life; some, who believe that the practice of surgery suppresses in the hearts of those who exercise it the gentler qualities of sympathy and finer sensibility. The truth is, nothing so cultivates the noblest human qualities, nothing exalts more the sense of pity,

sympathy and charity, than does an intimate knowledge of the causes and consequences of the processes of disease, nothing more stimulates tenderness than the constant contact with suffering and distress, by those whose training has taught them to gauge these in a manner far more subtle and just than is given to the ordinary well meaning but purely emotional observer.

These reflections apply with special stress when the surgeon is a man of the type of Professor Halsted; a man of gentle breeding, inherently courteous, kind, truthful, and, above all, exquisitely sensitive to his responsibilities.

* * *

Twenty years have elapsed since that memorable day, when, through a fortuitous circumstance, I became the fortunate beneficiary of Dr. Halsted's skill, and through his skill learned the full measure of his generous heart. Time has only confirmed these grateful impressions. As the years have rolled by, they have each come laden with the mellow fruit of his intellectual harvesting, so that now the fruition of his sowing is piled mountain high in enduring testimonial to his greatness.

Anyone, who has attentively followed the progress of surgery in our country during the three decades that Professor Halsted has presided over the surgical activities of this great school, finds it unnecessary to consult the *Index Medicus* for the information that his personal labors and example have left an indelible impression upon the history of Surgery, not only in America, but everywhere where the language of surgery is spoken and taught. Even if time allowed, it would be impossible, in the most cursory way, to review or mention all the salient contributions catalogued in his voluminous bibliography. Fortunately this herculean task is not needed, and indeed would prove superfluous in these sympathetic and congenial surroundings. Every surgeon who is familiar with Dr. Halsted's scientific accomplishments (and who is not, who is at all familiar with the literature of his profession?) must admit that if Dr. Halsted had given only *one* of the many discoveries with which he has enriched the science of his profession, it would have sufficed to immortalize his name. As it is, he has left a legacy that would crown the lives of a dozen great, but lesser, men!

That I may not be suspected of the partiality with which friendship so often magnifies our estimate of the merits of those close to us and whom we love, allow me to echo a voice that comes to us from the far away but which reaches us with clear, insistent tones, conveying a message from across seas, which is in gentle harmony with the spirit that animates us on this occasion. It is the clarion chant of Réné Leriche, surgeon of Lyons, France; himself, one of the foremost and most brilliant exponents of scientific surgery of his own country and of the present generation. A tireless worker and searcher. An operator of the highest order. Attracted by the world-wide reputation of the Departed Master, Leriche visited this great center of surgical learning. He came; he saw; he was convinced. Such a man is well entitled to speak

for his professional brethren at home and abroad, who, united by the kinship of ideas, ideals and high resolves for the advancement of their profession, recognize in Professor Halsted an international leader.

In an obituary, which appeared in the *Lyon chirurgical*, of October, 1922, Leriche has this to say of Dr. Halsted's passing:

Though it is not in the traditions of this journal to publish obituary notices of eminent surgeons other than those of Lyonnese birth, we have made an exception in Dr. Halsted, as I feel that the traits and characteristics of this good, simple, honest, modest man of kindly approach and exquisite courtesy, who was one of the greatest surgeons of his day, should be permanently recorded.

It is not only because he was one of the greatest surgeons of his generation that I think it a duty to render him special homage; not even because of the great debt which surgery owes him, more especially for the fundamental principles that he discovered,—as, for instance, his researches which have laid the foundation for regional anesthesia, which he formulated and demonstrated in 1884; his introduction of the rubber glove as a vital element in modern aseptic technic in 1889,—two rightful claims to his merit which alone entitled him one of the benefactors of humanity; but, it is chiefly because he was one of the very small number of those who have been able to enlarge the field of surgery, to elevate its standards to a nobler height, and to give back to Surgery more than he had received; to give her an impress and an impulse that will be felt for years to come. Others may have been more brilliant, more seductive, perhaps, more impressive to the passing visitor; but the impressions left by spectacular operators are ephemeral, transient, and easily erased; because generally those who are called great operators only leave their imprint upon the shifting sands of time. Halsted's performance was of a different sort. It is destined to endure and to last long after him, because he dealt with the understanding of things; because he built upon the very rock upon which the foundations of surgery rest, and upon which, as a branch of the healing art, it is based.

As an operator, Halsted, like Terrier and like Kocher, was the Father of a School of Surgery, which may be described as the Surgery of Safety; of a technic which sacrificed everything to the immediate and future success of the operation and the welfare of the patient. He put in force the most rigorous asepsis and the most uncompromising discipline in guarding the tissues from insult, by neglecting no details, no matter how small, that might compromise the issue and the thoroughness and finish with which he carried out the operative act.

Beginning at a time when surgery was still living under the spell of the preanesthetic days, when rapidity of execution was given the highest premium, he stood firm on the ground that the nature of the material upon which the surgeon exercised his handicraft is too noble and too precious to be insulted with impunity, or to allow even the smallest living particle to be wasted; that, to do this effectively, the surgeon must subordinate brilliancy and rapidity to safety.

I have elsewhere related what Halsted had accomplished in this direction, and I need not rehearse the story of his life work, but I will recall that from this point of view all the surgeons of our day, who are his pupils without knowing it, owe him a thought of gratitude.

As an investigator, Halsted understood surgery as an experimental science, aiming as his objective the greater and deeper knowledge of the laws that govern physiological and pathological life. It is difficult to express one's ideas without appearing to repeat mere truisms, but none the less, I say this advisedly, and as I feel it; the surgeon is too often only a mere technician, a man who, as the name implies, is one who works with his hands. For such a man, his intellectual exercise is chiefly an affair of comparing his own observations with other recorded or published precedents and from this comparison drawing his deductions. This is mainly a critical exercise, but not creative work. We often hear the surgeon

say, "It is my impression," "I believe," "I feel," "It appears to me." Rarely does he display the scientific spirit, the spirit of inquiry, which plunges deep beyond the surface in search for causes. He may even pride himself in being purely practical, so deeply impregnated is he with the contingent and relative character of his art. None the less, he is terribly dogmatic and his dogmatism, which is the continuous outgrowth of temporary impressions, blinds him to the fact that he has lost his intellectual independence and has become the slave of a vicious habit of mind. Halsted saw things differently. He saw a pathological and clinical problem everywhere that invited investigation and that he made the object of his experimental researches which he carried out with patience, painstaking labor and with all the discipline of a Claude Bernard. After settling on his problem, he thought it out to himself; he looked at it from every angle, but first objectively as a physiologist, then as a clinician. In speaking with him, one was surprised to discover all that he had sought to verify for himself, to control by experiment, to see clearly where the facts were leading him, long before he arrived at conclusions. On the other hand, one felt suddenly, almost as a revelation, what a huge gap there was in the classical methods of medical training and education—methods of instruction which appeal more to the memory than to reason and observation and which, in consequence, tend to waft the mind of the learner rather towards the knowledge of the past than to that of the future.

And then one understood how the good old master, of almost timid aspect, had remained always young in spirit; so alert, so open to new ideas; so inquisitive; so investigative, in all matters that were beyond the common ken and that required thought. He seemed always ready to suggest new researches, urging the young men who surrounded him ever onward, to explore untrodden paths and to blaze new trails, remaining unto the end the inspirer and the incomparable chief of a band of exceptional men.

* * *

Allow me to detain you for a brief space with a few reflections, suggested by the commentary, occasionally heard, that Dr. Halsted was not what is popularly described as a "brilliant operator," a statement which might be interpreted as depreciatory of his technical abilities by those who are unfamiliar with his aims as a surgeon and the principles that governed his operative acts. If by "brilliant" we mean the surgeon who utilizes his opportunities to dazzle the public with the prodigies of his skill, who listens for the plaudits of the multitude more intently than he does to the murmured approval of his conscience, and who burns his incense to the gods of the gallery, then, we must agree, Dr. Halsted was not one of that class. But, what do we mean by a brilliant operator? In the sense in which it is most commonly used, brilliancy is a quality whose chief characteristic is speed, the quickness and dexterity with which an operator executes and accomplishes the operative act. This is a quality in which our forefathers excelled, to acquire which they bent all their energies, and in which they vastly surpassed us. In this respect, we, the surgeons of the present generation, can no more compare our performances with theirs than we can make comparison between the speed of a horse car and that of a twentieth century limited railroad express. But when we consider the effects of a collision between horse cars, on the one hand, and railroad trains, on the other, including the wreckage that follows in each case, we may form some idea of the relative effects of speed as applied in the cyclonic operations of the older surgery and the calm but sure and safer motions of the surgery of the present. Happily for us and for humanity, the time has long

passed when surgical brilliancy and ability could be gauged by the clock, or when the relative merits of surgeons could be estimated by the rules of the prize ring or the authority of the Marquess of Queensbury. That was well enough in the dim days of antiquity, in the days of Galen and Celsus, when limbs of conscious men were amputated with an axe or a guillotine; or in much later days, when a Lisfranc, a Dieffenbach, a Lizars, or a Liston, could disarticulate a hip in five minutes or less, provided that in the flourish of blades, one or more of the assistants were not put *hors de combat* by the lighting maneuvers of the operator; or that one could say of a modern master what was said of Fergusson, who, in lithotomy, proceeded with such lightning speed and skill that someone advised a prospective visitor to his clinic to, "Look out sharp, for if you only wink you will miss the operation altogether!"

Then, time was everything, and any procedure that would relieve the patient of his encumbrance by the shortest route was at the highest premium. Before the discovery of anesthesia, the surgeon had to be a man with a heart of steel in order to carry on his work of relief in an atmosphere reverberating with shrieks and yells, lurid with blood, and laden with the germs of disease and death. Then, indeed, he was best surgeon who could slash off an offending limb in the quickest time. Then, indeed, brilliancy consisted in speed, speed at any cost, and the price of speed was high. As late as the early nineteenth century, the death rate was enormous, full 95 per cent and over for the hip; 70 to 80 per cent for the thigh, and so on. At present, by the modern methods of safety, it has fallen to an insignificant and negligible figure, in so far as the operative act is concerned. However, do not misunderstand me as depreciating the quality of speed when this is not a mere race for a record but is the legitimate outcome of dexterity, knowledge, system and method; the outcome of long experience and faithful practice in surgical exercises.

But, I do not reckon speed as brilliancy when displayed chiefly, if not solely, for spectacular effect; when it is exhibited at the expense of security, and when appraised as skill it is rated above caution and judgment at the hazard of the patient's highest interests.

Let us not forget that Surgery, as it is known today, was a *terra incognita* to the most daring and skillful surgeons of scarcely half a century ago. Operations that are now a part of the daily routine of every well established hospital would have seemed incredible to even such relatively modern masters as a Mott, a Bigelow, or a Gross and other renowned contemporaries of this period, who would be astounded at the temerity and seeming foolhardiness of their successors.

Professor Halsted, himself, has told us (Yale Address, 1904) that "in 1876, the year I first walked the wards of Bellevue Hospital, New York, the dawn of modern surgery in America had hardly begun." The discovery of ether was not so old as to have obliterated all traces of the surgical rule, "*Tuto, Cito et Jucunde*," but the rapid method of operating was slowly

giving place to safer, more conservative and deliberate procedures. In fact, it was not until a whole decade had elapsed after the introduction of antiseptic surgery by Lister (1878 to 1888) that the changed conditions wrought by anesthesia, antisepsis and asepsis were actually realized by the mass of the profession. It was only then that the systematic invasion of the great body cavities began and when the pelvis, the abdomen, the thorax, and the cranium gradually surrendered their contents and became amenable to the laws of surgery.

With anesthesia and asepsis as the master keys, experimental surgery received a new impetus and the horizon of surgery rapidly expanded. Roentgen's discovery of the x-rays then came in 1899–1900 to inaugurate a new epoch in surgery and, by illuminating the body, incredibly multiplied the indications for surgical intervention. The rays and the collaboration of the physiological, biochemical, bacteriological and pathological laboratories have all combined to so transform the entire face of surgery that it is no longer recognizable in the light of its ancient portraitures.

The number of operations has not only multiplied[3] but new operations have been added and are being devised which could not have been attempted in the pre-Listerian period and which were unthinkable and entirely beyond the conception of the older operators.

[3] In his previously mentioned Yale Address, 1904, on *The Training of the Surgeon*, Professor Halsted, in drawing a parallel between the old and the new surgery, called attention to the small number of operations performed fifteen years before the date of his address—that is, thirty-four years ago—and their progressive and enormous increase ever since that time. He quoted the pre-Listerian experience of Billroth, Thiersch and v. Mikulicz to show what comparatively little operating was done in the great hospital centers of Austria during the forbidding days of sepsis and which subsequently, after Lister, became the theatre of the greatest surgical activity. In 1900, v. Mikulicz wrote him from Breslau: "When I was a student in Vienna, there were days, particularly in winter, when not a single operation occurred in the University Clinic, so scarce was the operative material." Quoting the statistics of the Massachusetts General Hospital, he states "that in the entire decennium prior to the discovery of anesthesia, only 385 operations were performed in the hospital—an average of 38.5 operations a year. In the first decade subsequent to the employment of ether, 1893 operations were performed—an average of 189 per year. In the decade preceding Lister's visit to this country (1876), from 1868 to 1878 there were 7696 operations. In the next decade only 10,119 operations were performed, but from 1894 to 1904, there were 24,270. In the single year 1903, over 3000 operations were performed in the same hospital." The Boston City, Roosevelt, and New York Hospital showed an increase in similar proportion, and this experience is repeated all over the world. The Charity Hospital of New Orleans, an institution which dates its existence to 1832, shows a record of only 172 operations in 5309 admissions during the year 1881, or a little over 3.2 per cent of the total patients admitted, and of these, 72 were amputations, 23 incisions for abscess 18 extractions of bullets. *One single laparotomy.*

In comparison, we find that in 1923, 42 years later, in a total of 20,565 admissions, there were 16,405 operations, an increase of 79.7 per cent! Practically 80 per cent of the patients admitted in 1923 had furnished indications for surgical intervention! In other words, the treatment of disease in the hospital, which in 1881 had been a little over 96 per cent *medical* or *pharmacal*, in 1923 became 80 per cent surgical.

Again, we should remember that many of the most difficult and dangerous operations, made possible through the advances of contemporary surgery, are still only made safe by the exercise of the greatest caution coupled with most consummate skill.

Such undertakings consume time and, if speed is to be the criterion of brilliancy, the surgeon who performs these operations—no matter how successfully—can never be called "brilliant." And it is precisely this class of cases in which Professor Halsted was engaged!

According to my understanding, brilliancy in surgery lies more in the results of the surgeon's intervention than in the immediate act. To my mind *he* is the most brilliant surgeon, who, in equality of circumstances, saves or prolongs the greatest number of lives and who restores his patients to health in the shortest number of days.

The brilliancy of the operator should not be appraised by the time he consumes in the performance of an operation, but by the effect that follows its achievement; not in the mere recovery of the patient from the immediate operative act, but in the way in which he recuperates; in the length of time required for his recovery; in the period demanded to restore him to usefulness, and, above all, in the permanency of the cure which it accomplishes.

It is in this manner that I would rate and compare the brilliancy of surgeons, and it is from this viewpoint that Halsted is considered one of the most brilliant and greatest surgeons of his time. It is the sort of brilliancy at which he aimed and with which he sought to imbue his pupils through his teachings and example. It is the sort of brilliancy for which every conscientious surgeon—who places his patient's welfare and the good repute of his profession above the vanity of his own flesh, should strive.

* * *

It has been said that Dr. Halsted leaned more to the Science than to the Art of Surgery. This no doubt, so far as his natural inclinations were concerned; but it is difficult to decide which of the two he benefited the more. When we consider what he did for Surgery as a craft and compare the technic of Surgery as he found it, when he made his first appearance in the surgical arena scarcely more than forty years ago, and how he left it at his death; when we consider what he did for the three fundamentals of Surgery—hemostasis, anesthesia and asepsis, in each of which he was not only a pioneer but an innovator, whose discoveries have, in many ways, transformed the entire face of the handicraft of Surgery, we have, indeed, reason to pause before expressing judgment.[4]

[4] Those who have not been privileged to see Dr. Halsted actually at work in his clinic may be able to gain an insight into his qualities as a technician by reading his paper, admirably illustrated by Broedel, in the *Journal of the American Medical Association* for April 12, 1913. In this paper, Dr. Halsted gives a most interesting account of the several methods which were peculiar to his clinic and which he originated. In this he gives convincing reasons for his preference for fine silk over catgut, and his results amply justify this preference. The history of the rubber glove as introduced by him in 1890, now universally recognized as the most important adjunct in the practice of

Need I cite examples to prove Professor Halsted's inventiveness and his influence in remodeling and recasting the older technic of Surgery as he found it, and how much he did to elevate it to the present marvelous state of efficiency? But if this is what he did to improve the methods that are fundamental and common to all modern operations, how can we question his profound interest in the art of surgery in the face of the evidence that he has given us of his perpetual concern in improving and perfecting the art as applied to more complex and major operative problems? Need I recall what he did when he revolutionized the surgical treatment of cancer of the breast scarcely a quarter of a century ago? Did he not show then, by the thoroughness of his methods, that the older technic of the operation could be so greatly improved that the percentage of local recurrences—which had up to that time ranged between 59 per cent (Volkmann) and 85 per cent (Billroth)—had dropped in his hands to the low figure of 6 per cent, and if the regional recurrences, away from the field of operation, were included, the combined total of local and regional recurrence, after three years observation, did not exceed 22 per cent!

The publication of Professor Halsted's first paper in 1895, which described the details of his technique and which showed the results that he had obtained by his method since 1889, brought with it a new message of hope for the victims of cancer and stirred the surgeons of the world with renewed ardor in the pursuit of this implacable disease. His results, as first published, clearly show that the old traditional saying, "Cancer of the breast is operated upon, but not cured" was erroneous and that by operation the disease could be positively eradicated from its original focus of invasion. In other words, the doctrine that cancer is primarily a local disease and can be permanently rooted out, if only attacked before it has migrated to inaccessible localities, was now proven to be true far more conclusively than ever before. But even more, his results showed that when it had advanced to what were usually regarded as its impregnable intrenchments, the apex of the armpit and the neck, there was still hope of

surgical asepsis, the "boiled hand"; his use of gutta percha tissue for the protection of granulating wounds and for the prevention of adhesion of dressings and drains to the tissues (the present cigarette and cigar drains, so generally used, are of his making), and the use of silver foil and a number of ingenious and original modes of suture, are all described in Dr. Halsted's inimitable style. His use of fine straight cambric and milliner's needles, split-eyed, which were kept threaded with fine silk in long rows on sterile towels ready for immediate use, was a distinct peculiarity of his clinic. In this connection, Dr. Adrian S. Taylor, Professor of Surgery at the Medical College of Pekin, has contributed a paper (*China Med. Jour.*, xxxv, September 5, 1921), which will prove interesting to those who desire a detailed account of Dr. Halsted's methods, especially in the use of silk in surgery, as they are now practiced by one of his most successful followers in the far East.

Garrison in his *History of Medicine* (1913, p. 264) admirably sums up Professor Halsted's accomplishments as a technician in the treatment of surgical wounds: "Quietly and unobtrusively, Halsted has taught the perfect healing of wounds which has been nowhere more beautifully illustrated than in his clinic."

cure, if the operation was thoroughly performed, as he did it. The result of Dr. Halsted's work was that he synthetized the best points in the techniques that had been suggested by the most advanced workers and he added new principles and procedures which contributed to the thoroughness of the extirpation. It was in the completeness of his method that he achieved a success which set a new pace in the progress of breast surgery, and established a standard of efficiency which had no precedent in the history of this malignant disease.[5]

There are many of us who recall "an amputation" of the breast for cancer, as it was classically performed in the late seventies and early eighties. The operation was then a mere mammectomy, performed in fifteen or twenty minutes, or less, with a few rapid and sweeping strokes of the knife. It was a quick, "brilliant" but bloody affair, in which the diseased mamma and underlying fascia were removed, with here and there an obviously diseased axillary gland. There was no effort to remove the breast and tributary areas in block dissection, or systematically to pursue or ferret out the disease in all its known hiding places or routes of travel. The wounds were usually easily closed as there was ample skin left to cover the incision completely without leaving bare surfaces.

Then the operation was performed chiefly for palliative effect—only with the hope of prolonging life, but not for cure. At best, the prolongation of life after operation was short. Sir James Paget, in an early publication, estimated this gain of life at four months. In a later paper, he extended the average postoperative expectation of life to twelve months. Other observers of the same period estimated it at ten months (Gross), thirteen months (Morrant Baker), twenty-two months (W. R. Williams), thirty-one months (Sibley). Quite often, the disease recurred in the wound before it had time to heal. Some surgeons of the greatest experience (such as Agnew) frankly admitted that they had never been able to cure a cancer of the breast by operation or by other means. Many surgeons did not share in these extremely pessimistic views and there were individual groups of statistics which showed the error of this conclusion. In fact, many patients survived not only three years without recurrence (which Volkmann had proclaimed as a test of "cure") but five and more years. These results, however, were exceptional and it was only after Halsted had enunciated the principles upon which his operation

[5] In an admirable study of "Cancer of the Breast," published in Paris in 1913, Baumgartner thus refers to Dr. Halsted's work:

"By combining and selecting the best suggestions offered by the most advanced operators [and adding many new and important details of his own] the American surgeon, Halsted, elaborated a surgical technique which gave a powerful impulse to a more radical and extensive extirpation of cancer of the breast. The operation he devised was quickly adopted, wholly or with variations, by the majority of surgeons the world over. . . . . Halsted's operation, or any other that approaches it, which is based upon the principles that govern it, is amply justified by its [superior] results, as shown by all published statistics." (A. Baumgartner, Maladies de la mamelle. *Nouveau Traité de Chirurgie*, Le Dentu-Delbet, 1913, xxlii, 270.

was based and after its feasibility had been demonstrated that the number of cures of three, four, five years and much greater duration multiplied in all the clinics of the world until now they have ceased to be a novelty and can no longer be counted.

While the cure of cancer in the breast and elsewhere is dependent upon innumerable factors entirely unconcerned with mere surgical technique and still remains a problem which awaits solution and intensely preoccupies the minds of all surgeons, the fact remains that, in spite of the great gains that in recent years have been made in its treatment by the acquisition of radium and x-ray therapy, the only hope for a victim of cancer of the breast lies in the *early* and thorough extirpation of the disease by the knife, in the way planned and carried out by Halsted.

No one who has been privileged to see Dr. Halsted at work on a cancer of the breast, especially during the period between 1895 and 1908, when his publications had attracted many visitors to his clinics to study his methods, could fail to recognize the reason for his extraordinary success. Deeply interested in his work and absorbed in all its details, whether operating himself or directing his staff of well trained and brilliant assistants, his delicate but far reaching dissections, by which he pursued the disease relentlessly, without regard to esthetic effect or plastic union; his minute and almost fastidious precautions against infection and hemorrhage, controlling the smallest bleeding point so that the total blood loss throughout the operation was negligible; his skill and nicety in covering large skin defects with autogenic skin grafts in a way that has scarcely been equalled and has never been excelled, and his final dressing of the wound, covering it with silver foil and with immobilizing plaster dressing, gave the impression to the onlooker that he was seeing the performance of an artist close akin to the patient and minute labor of a Venetian or Florentine intaglio cutter or a master worker in mosaic. Yet this task, which with all its discipline and method often consumed two and three hours, was practically shockless and bloodless and was followed almost invariably by recovery.

In May, 1907, he reported to the American Surgical Association, 232 cases of cancer of the breast operated upon in Johns Hopkins Hospital by his method, with a total postoperative mortality at the hospital of 1.7 per cent! Of the total number, 89 patients (42.3 per cent of 210 traced cases and 38.3 per cent of 232) were living, free from recurrence and apparently cured, three to five years after the operation.[6]

[6] Dr. Bloodgood, to whom Dr. Halsted often "expressed his obligation for his efficiency and inexhaustible zeal in collecting the statistics of his operation, year after year, for so many years" further elaborated (in 1908) the statistics of his Chief as follows:

"The statistics in Halsted's clinic up to the present time show among 210 cases, in which three years and more have passed since the operation, that 42 per cent are apparently well. If we consider the cases in which the axillary glands, studied microscopically, showed no evidence of metastasis, 61, or 85 per cent are well. In cases in which the axillary glands showed metastasis (110), 30 per cent recovered, free from recurrence for three years. When the

Anyone seeing Dr. Halsted at work was impressed with his "capacity for taking infinite pains." When he had finished his task, the departing visitor realized that Surgery, in his hands, had made her supreme effort to save the victims of cancer of the breast.

The same interest, originality and practical value is displayed in the technic which he evolved for skin grafting, for the suture of wounds, for the radical cure of hernia, for the resection and suture of the intestines, for the drainage and suture of the common bile-duct (at a time when most men were limiting their interventions to the gall-bladder and the cystic duct[7]). His operation on the thyroid for the cure of goiter remains today a triumph of surgical technique. His most delicate and highly anatomical procedure of the ligation of the inferior thyroid arteries which, in spite of its superiority, few men have adopted, because the upper bipolar ligations are so much easier! His success in the ligation of the great and most dangerous arteries (aorta, innominate, subclavian, carotid, iliac). His ingenious device for the partial and progressive occlusion of the aorta and other great vessels in the cure of aneurism,[8] all of these are living, palpable testimonials of his love of the

glands in the neck showed metastasis (40 cases), only 10 per cent remained well for three years.

"In all of these groups, metastasis has been observed after an interval of three years of apparent cure. Such late metastases may take place up to eight years after operation. Excluding these cases of late recurrence, the number of definitely cured in these three groups is reduced to 75, 25, and 7 per cent, respectively, or for all cases together, 35 per cent." (*Amer. Jour. Med. Sciences*, February, 1908.)

[7] In February, 1898, Dr. Halsted performed the first recorded and successful operation for a primary carcinoma of the papilla of Vater. The patient was a woman sixty years old. In this operation, probably the most difficult and dangerous in hepatic and intestinal surgery, he excised part of the duodenum (nearly its entire circumference) pancreas, common bile duct and pancreatic duct, in order to give the little growth, no larger than a pea, a wide berth. After the excision of the tumor, the operation was completed by a circular suture of the duodenum and transplantation of the common duct and pancreatic duct (Wirsung) into the line of suture. Two months later he supplemented the operation by creating an anastomosis between the gall-bladder, cystic duct and duodenum (cholecystduodenostomy). The patient recovered fully from the operation, but finally succumbed months after to a recurrence of the cancer in the pancreas and the cystic duct.

This, at that time, a unique case, was reported together with a number of other remarkable operations in his "Contribution to the Surgery of the Bile Passages, Especially to the Common Bile Duct," read at the Suffolk District Medical Society, Boston, May 3, 1889 (*Johns Hopkins Hosp. Bull.*, January, 1890).

[8] Dr. Halsted was the first surgeon to ligate the left subclavian in its first division successfully (May 10, 1892). He again performed the same ligation (intra-thoracic) successfully, on April 26, 1918. In this case (a huge subclavian aneurism), he also ligated simultaneously the left carotid, ligating both vessels near their aortic origin. This is probably the largest subclavian aneurism ever operated upon. Two years after the ligation he excised the sac, which had remained and was beginning to relapse—also with complete success.

He had ligated the subclavian, in all, six times for aneurism, including two ligations of the first division of the left subclavian, followed in both instances by a secondary extirpation of the sac. "The patients all recovered ideally without gangrene or added loss of function; the wounds all closed without drain, healed

art as well as the science of his profession.[9]

In every region of the body, in addition to the extremities, and in every advance that has marked the progress of surgery in the last thirty years, we find the impress of his hand and the reflex of his brain. In the abdomen, in the thorax, in the neck, in the extremities, are stamped the indelible marks of his passage, always moving onward in search of new discoveries and new conquests.

In the surgery of the brain and nervous system, in which his literary contributions figure less prominently, it is none the less *his* technique, *his* methods and doctrinal ideas of thoroughness, scrupulous asepsis, absolute hemostasis, delicate handling of the tissues, avoidance of gross material, and artistic finish in the final closure and dressing of his wound, that is reflected in the work of his gifted pupils, Cushing, Heuer, and Dandy, to whom, in succession, he intrusted

per primam, and, in all, the aneurism was cured" (Ligation of the Left Subclavian, *loc. cit.*, p. 15). He also ligated the innominate five times, all the patients recovering.

He was the first to occlude successfully the *thoracic* aorta for high abdominal aneurism with a partially occluding aluminum band (December 18, 1906).

The thorax was opened and the aorta exposed under positive pressure with an apparatus devised by his assistants, Follis and Fisher, and successfully applied the band 7 cm. above the diaphragm. Twenty-three days later, he applied another aluminum band to the abdominal aorta of the same patient, distal to the aneurism just below the inferior mesenteric artery. The patient survived eighteen days after the second operation. In another case he again constricted the abdominal aorta with an aluminum band on February 23, 1909, for an enormous aneurism of this vessel. The band was applied above (cardiac side of) the renal arteries. The patient succumbed on the forty-first day from infection of the aneurismal sac.

In the two operations on the aorta performed by Dr. Halsted, the fatal termination was due in each case to unavoidable complications, but not to defects in the technique.

[9] Dr. Halsted's deep interest in matters of pure technique remained undiminished to the very last. His paper on "Blind End Circular Suture of the Intestines, Closed Ends Abutted and the Double Diaphragm again Punctured with a Knife Introduced Per Rectum," was published in the *Annals of Surgery* for March, 1922, six months before his death (September 7, 1922). Of this procedure he wrote me in a personal letter (August 24, 1921): "A few days ago I sent you a package of photographs made by Max Broedel, to illustrate a clean and very simple method of making an end to end intestinal suture which I worked out last winter. This operation was performed upon 46 to 48 dogs (large intestine) by others as well as myself (Reichert, Holman, Mont Reid) and without fatality. By no other method have I obtained such ideal results. To test the relative merits of the various methods of suture one should make an early examination of the peritoneal cavity twelve, twenty-four, and forty-eight hours after the operation. Only by these early examinations can we get an idea of the reaction and of the part played by Nature in overcoming the errors and bad methods of the surgeon."

This contribution and his paper on the "Replantation of Entire Limbs Without Suture of the Vessels" which appeared in the *Transactions of the American Surgical Association* for 1922, and in the *Proceedings of the National Academy of Science* in July, 1922, are the last contributions which he gave to the Scientific world, and it is fitting that these two papers which were typical of his attitude of mind and his habitual mode of approaching surgical problems should have appeared almost simultaneously at the close of his career, so true were they to his two paramount interests in his professional life, the culture of Surgical Art guided and controlled by Experimental Science.

and virtually relegated the development and teaching of neurologic surgery in Hopkins.

The achievements of this department have contributed some of the finest gems to the crown of modern neurologic surgery, and while they are unquestionably due to the genius of the brilliant men who have presided over it, it cannot be doubted that the stimulus of Dr. Halsted's example as an investigator, his proximity, and the suggestiveness of his observations have served to spur the men whom he had chosen for this special task, to their best efforts.[10]

Dr. Halsted attacked every problem that came before him right at the foundation. He was not satisfied with the mere superstructure, with the shaft or capital of the column. He would not rest until he was assured of the security of its base, and then when this was done he would build a shaft and capital of Corinthian beauty, so finished and perfect in all its parts, that the world looked on with admiration when he had finished his work.

* * *

The tendency of surgery today is to lean too much towards mere craftsmanship, mere mechanical expression, mere technic. Admirable and necessary as is the cunning of the hand, its obedience to command is not all. Something more is required. As stated by Sir T. Clifford Allbutt, the most learned living exponent of medicine in England, in his memorable address "On the Historical Relations of Medicine and Surgery," delivered in this country nineteen years ago:

> The union of art and science is far from being, as too often we suppose, one merely of the wind and helm; it is one rather of wind and wing. How these two functions, science and craft, hand and mind, should live in each other, we see in the fine arts, in the swift confederacy of hand and mind, in Dürer, Michael Angelo, Velasquez, Rembrandt, Watteau, Reynolds, Watts, only to mention the great masters of the past. Equally as well in the domain of music, Lizst, Mozart, Shubert, Haydn, Beethoven, Chopin, and others who have excelled in imagination and composition as well as in pure technical execution.
>
> The infinite delicacy of the educated senses is almost more incredible than the compasss of the imagination. When they unite in creation, no shadow is too fleeting, no line too exquisite for their common engagement and mutual reinforcement. The craft of a Verrocchio becomes the magic of a Leonardo da Vinci and Michael Angelo; in genius perhaps the greatest craftsmen the world has ever seen, they were as skilful to invent a water engine, to anatomize a plant, or to make a stone-cutter's saw, as to paint the lineaments of the soul and to build the dome of St. Peter above the clouds; of Christendom.

It is the harmonious unison of mind and the senses, the hand and the head,

[10] In confirmation of the above statement and of the suggestiveness of Dr. Halsted's observations, the following quotation from one of Dr. W. E. Dandy's early contributions on "Ventriculography Following the Injection of Air into the Cerebral Ventricles" (*Annals of Surgery*, July, 1918)would seem appropriate:

"*It is largely due to the frequent comment by Dr. Halsted on the remarkable power of intestinal gases to perforate bone, that my attention was drawn to its practical possibility in the brain.* Striking gas shadows are present in all abdominal and thoracic radiograms. From these and many other normal and pathological clinical demonstrations of the radiographic properties of air, it is but a step to the injection of gas into the cerebral ventricles—pneumoventriculography." This is one of the many examples of how Dr. Halsted scattered about his germinal ideas.

science and craft, exhibited in the supermen who have exalted the fine arts, from antiquity to the present time, that we find the ideal, difficult to attain it is true, that should be in the mind of those who aspire to the mastery of our profession.

Without pretending to soar with genius to the heights of the empyrean, which is given only to a chosen few, the surgeon, as an exponent of the greatest of the liberal arts—the sculptor and moulder of "the human form divine"—needs cultivating the subtle touch, the conscient finger and the obedient hand even more than the sculptor, the painter, the musician or other interpreters of art in baser materials.

But, even more, he needs the broad vision, the cultivated imagination, the catholicity of artistic taste and human sentiment, that give to his manual accomplishments the attributes and qualities that glorify the hand in the higher arts. To *do* all this and to *be* all this, the Master Surgeon must be a man of mind, a man of thought, a man who knows his province, the human body, as a whole and not only one of its parts.

That grand old Master Chirurgeon, Henri de Mondeville, as far back as the thirteenth century, seven hundred years ago, said:

> It is impossible to know perfectly the part, if one is not acquainted with the whole, even in a gross way (*grosso modo*); so it is impossible to be a good surgeon if one is not familiar with the foundations and generalizations of medicine. On the other hand, as it is impossible to know the whole perfectly if we are not acquainted in a certain measure with each of its parts; it is impossible for anyone to be a good physician who is absolutely ignorant of the art of surgery, with a knowledge of its possibilities and its limitations.

It is in this sense, that the surgery of the twentieth century is ploughing its way to the fulfilment of its greatest destiny. It is in this way that the art of the surgeon, guided by the light of science, has risen from a low state of almost abject subserviency to its present commanding position. It is by following in the wake of scientific progress, by utilizing every advance in each one of its elementary and ancillary branches—anatomy and histology, biology and physiology, physics and chemistry, pathology and bacteriology—that surgery has sought and found light in the solution of its many and complex problems.

It is with this understanding and in this sense that our great friend understood surgery. It is in his broad comprehension of and in his capacity to utilize the data furnished by the collateral sciences in their application to surgical problems, that Professor Halsted occupies a unique and prominent position in the surgical world, and that gives enduring luster to his fame.

* * *

The problems of the vascular system, especially of aneurism, had a great fascination for Dr. Halsted[11] and on

[11] Dr. Halsted's interest and the importance attached to the surgery of the vascular system is understood in the light of the following paragraph. "True also it is, as I have so often said, that the surgeon's method of dealing with the blood vessels is a criterion of his proficience in his art" (Ligation of the Left Subclavian, *loc. cit.*).

Dr. Halsted evidently agreed with Ballance and Edmunds in their monumental

these he brought to bear all the resources of his keen critical faculties[12,13] and of his splendid training in anatomy, physiology and pathology, which he invariably supplemented or initiated by illuminating experiments which he performed himself or with the collaboration of a group of most able and faithful assistants. In this, as in all his numerous scientific researches, his experimental work was conducted in the Hunterian laboratory which has been made famous throughout the surgical world by the many and enduring contributions that have emanated from it. From all of these, important deductions followed, which left a residue of precious metal in the treasury of Science. For instance, his now well known generalization, referred to as Halsted's Law—that a transplant of a portion of a ductless gland will survive only when a physiological deficit has been produced. This he evolved out of his experimental work on the thyroid, parathyroids and thymus. His researches on the causes of the dilatation of an artery on the proximal side of an arteriovenous fistula, and the probable extension of this change in the arterial walls from the fistula upwards toward the aorta and even the heart, and, conversely, the reasons why an artery dilated on the distal side of a constriction in its lumen, which he was the first to observe, accounts for the predisposition to subclavian aneurisms when this artery rests on a cervical rib, roused new interest in a hitherto unsuspected pathological condition and paved the

work on the "Ligation of the Great Arteries in Continuity," (1891), when they began their chapter on the history of the ligature by stating that "the surgery of the arteries is the very foundation of Surgery."

[12] Dr. Halsted's reflective mind and philosophic attitude toward surgical problems are well illustrated in the following passage from his masterly monograph on the "Ligation of the Left Subclavian Artery:" "What surgeon called upon to treat a large aneurism of the neck or groin has not experienced the disturbing sensations which only such tumors can arouse? When confronted with an inoperable malignant neoplasm one feels the great pity of it, but not, as in the case of an aneurism, a peremptory challenge to face the exigency and cope promptly with a situation demanding skilful, resourceful and possibly even a temerous intervention. Few of the surgeons to come will have occasion to be stirred as Valentine Mott must have been by his dramatic experience in ligating the common iliac artery. The surgeon of today looks rather to Science than to his art for stimulating rewards of his endeavor. In ligating the first portion of the left subclavian within the chest the operator may not, as formerly, be more greatly impressed by the magnitude and cleverness of his performance than by the miraculous effect of the ligation of the artery upon the great, pulsating tumor which with each beat of the heart jarred the whole frame of the sufferer.

"The moment of tying the ligature is indeed a dramatic one. The monstrous, booming tumor is stilled by a tiny thread, the tempest silenced by the magic wand." (*Johns Hopkins Hosp. Reports*, vol. xxi, p.5.)

[13] "One of the chief fascinations of surgery is the management of wounded vessels, the avoidance of hemorrhage. The only weapon with which the unconscious patient can immediately retaliate upon the incompetent surgeon is hemorrhage. If he bleeds to death, it may be presumed that the surgeon is to blame; whereas if he dies of pneumonia, peritonitis or other infection, or from an unphysiological operative performance, the surgeon's incompetence may not be so evident." (Halsted: "The Effect of Ligation of the Common Iliac on the Circulation and Function of the Extremity." *Trans. Amer. Surg. Assoc.*, vol. xxx, 1912.)

way for further research and clinical application.

The qualities of thoroughness, absolute scientific honesty, accuracy, and vision, which characterized Dr. Halsted in all his clinical undertakings, likewise distinguished his experimental work and gave to his conclusions the greatest value. His investigations into the effect of the partial and complete occlusion of the aorta and other great arteries, by constricting them with an aluminum band, strips of fascia or of aorta, and the study of the effects of arterio-venous aneurisms on the heart, which were undertaken by Mont Reid under his direction, and other investigations of a like character, too numerous to mention, are characterized by the same rigid discipline which, as Leriche puts it, would have been worthy of a Claude Bernard. In these researches, he was even greater as a physiologist than as a surgeon.

Perhaps to the public, his most sensational achievements, in connection with the problems of the circulation, is his report of the successful transplantation and reimplantation of the amputated legs of dogs, without restoring the continuity of the divided blood vessels, an experimental feat which was accomplished under his direction by his assistants Reichert and Reid, and is among the latest of his contributions. This performance has been done previously by Carrel and others, but always conditioned on the reëstablishment of the circulation in the main vessels of the limb by arterial suture. Thus the miracle of transplanting the leg of a negro slave to the amputated stump of his white master, which is a part of the traditions that encircle the lives of Saints Cosmas and Damian, has actually been brought within the pale of possibility by Dr. Halsted's demonstrations in the lower species. In connection with this miraculous operation, a little note, quoted from Osler, is interesting:

> These practitioners, who became the Christian saints of surgery, suffered martyrdom in Cilicia in the third century. In their western mother church in the Roman Forum, I have seen the little parcel, said to contain the instruments with which they performed the most famous operation in hagiological surgery—substitution of the healthy thigh of a just dead man for one that was gangrenous. (*Lancet*, May 8, 1915.)

* * *

The one surgeon Halsted perhaps admired more than any other was the late Theodor Kocher, of Berne, Switzerland. We are told by Cushing, who had studied under both masters and who knew them perfectly, that "the two men, in manner and methods surgical, in imagination and ideals, had very much in common. Both of them held their professorships for an unusual number of years—Kocher for forty-five years and Halsted for thirty-three years." This opinion is fully confirmed by the following note of appreciation which appears very appropriately in Halsted's "*Operative Story of Goitre*" (1922).

> Many times during the past twenty years I have stood by the side of Professor Kocher at the operating table, enjoying the rare experience of feeling in quite complete harmony with the methods of the operator, and it is a pleasure to give expression to the sense of great obligation which I feel to this gifted master of his Art and Science.

As his eminent pupil, Cushing, who had exceptional opportunities for observing the characteristics of his great teacher, has well said: "He had a rare form of inspiration which sees problems, and the technical ability combined with persistence which enabled him to attack them with a prospect of successful issue."

In this respect, Dr. Halsted's investigative and analytical turn of mind reminded one of John Hunter, for whom he had the greatest admiration and of whom he once said, "John Hunter's name is eclipsed by that of no other surgeon, and for the fame of his contributions, particularly to biology and physiology, an inextinguishable lamp will forever burn." (Yale Address, 1904.)

Not unlike Hunter, he could well say, when facing an obscure problem which could not be solved by mere theorizing, "Why think? Why not try the experiment?" How faithfully Halsted exhibits the workings of his own mind when, in speaking of Hunter, he said: "How fascinating to follow the groping in the dark and the searching light of a great mind! How refreshing, and what a lesson is his honest doubt!"

* * *

Dr. Halsted's literary productions were characterized by the same distinctive, painstaking thoroughness and attention to detail which distinguishes all his work. His major monographs on the *Surgery of the Intestines*, on the *Radical Cure of Hernia*, on the *Surgical Treatment of Cancer of the Breast*, on the *Common Bile Duct*, on the *Surgery of the Left Subclavian*, on the *Effect of Ligation of the Common Iliac Arteries*, on the *Significance of the Thymus in Graves' Disease:* his collected papers on the parathyroids, his *Operative Story of Goitre;* on the *Partial Occlusion of the Aorta and Other Great Arteries with Aluminum Bands*, are examples of contributions[14] which are universally recognized as epochal in importance, not only in virtue of their originality and suggestiveness, but because of their searching analysis of the experiences of other operators as they are recorded in the literature. His complete monographs represent an immense amount of bibliographic research; not mere compilations, but critical analyses, with commentaries and criticisms on each case which add immensely to the value of the compilation. His comments and criticisms, usually short and pithy, are always illuminating and contain the very kernel of the knowledge one is seeking, and reflect the mind of the man who knew every inch of the ground that he was treading upon.

The great labor and time required in the preparation of his opera magna necessarily limited his literary output to a relatively small number of yearly productions, but each one of these works is a landmark in the history of the subject. He was well aware that the surgical world had learned to expect great things of him, and he spared no labor to rise above the level of the highest expectation.

To the *cognoscenti*, in the highly technical subjects which engaged his

[14] No attempt is made in this address to quote exact titles or references as these will appear in the complete Bibliography which is to accompany the two volumes of Professor Halsted's *Collected Papers*, now in course of preparation by Dr. W. C. Birkett, under the editorship of Dr. William H. Welch.

attention, the appearance of one of his books or papers was always an event which promised an intellectual feast, rich in vitamines, which was to be degustated with delight but which had to be assimilated slowly. His shorter papers gave an account of the gist and trend of his activities. His pupils and co-workers often supplemented his initial and germinal ideas which he furnished in abundance, like the acorns of a giant oak from which spring other trees, vigorous and strong with the sap of the primal trunk.

Modest, self-repressed, shunning the limelight of publicity, he never obtruded his personality or exploited his merits or achievements as claims for priority, only referring to himself in the most impersonal way and always allowing the facts to speak for themselves. In this he seems to have inherited the Baconian precept that, "A man can scarce allege his own merits with modesty, much less extoll them. . . . . Such things are graceful in a friend's mouth which are blushing in a man's own."

Cushing is right when he describes Halsted as an aristocrat in his breeding, for if there was anything that he detested most cordially it was vulgarity, coarseness and undue familiarity. Though over modest and retiring, he had a full consciousness of the dignity of his rights; "Mens sibi conscia recti" expresses his attitude of mind as he walked through life.

Though shy and reserved and undemonstrative, caring little for the "gregarious gathering of men" as Cushing well expresses it, and living largely to himself in his home, his laboratory, and his clinic, he delighted in the company of his pupils, immediate associates and a few chosen friends. With these, he was expansive and the glow and warmth of his friendship melted whatever restraint had been imposed upon those who first approached him and who were kept at a distance by his punctilious politeness and adhesion to conventional formalities. To those who were privileged to bask in the sunshine of his friendship, the true nature of the man was revealed in all its splendor. When he allowed his mind to expand freely in confidence, without restraint, his breadth of thought, his wide culture, his intimate knowledge of the greatest leaders of the profession throughout the world, whom he met in his frequent travels, added to the amenity and suggestiveness of his conversation. Generous, liberal, and hospitable to a fault, his kindliness, sympathy, and unequalled liberality in helping the younger men to accomplish great undertakings, by encouraging them through privileges and opportunities which he secured for them, are all qualitities which account in a great measure for the admiration and loyalty that is so notably displayed by his pupils and associates—an admiration, love and loyalty that only grew deeper and stronger as the years rolled by.

I cannot think of Professor Halsted without associating him with his pupils and collaborators. I see him as the central figure in a great historic painting. I see him as I have seen Ambroise Paré holding the ligature in hand, spurning the hot iron and boiling oil on the battlefield of Metz, as depicted in the great panel at the Ecole de Médecine at Paris. I see him as we have seen John Hunter and

his pupils; as we see Claude Bernard in his laboratory in the Collège de France; as Velpeau is depicted, demonstrating a great lesson in surgical anatomy; as Billroth stands surrounded by his devoted coterie of assistants and pupils—all destined to be the greatest leaders in the Austrian and German Universities. I see him like Pasteur, surrounded by his pupils and associates (Duclaux, Roux, Chamberland, Metchnikoff, Calmette) and again in the grand tableau representing the meeting of Pasteur and Lister in the great amphitheatre of the Sorbonne, together receiving the homage and plaudits of the assembled representatives of the civilized world (1892). I see him as Péan is seen, demonstrating the control of hemorrhage in operations by forcipressure at the Hôpital International. I see him as v. Bergmann, head of German surgery, operating at the Charité in Berlin surrounded by his now famous pupils; as Felix Guyon and his staff at the head of the great school of genito-urinary practice at the Hôpital Necker; as Trousseau, surrounded by a group of his pupils, all exceptional men and teachers, all attached to him by ties of the deepest affection. I think of him as I see Gross at Jefferson; Agnew at the Pennsylvania Hospital, Bigelow at the Massachusetts General Hospital. These are great historic pictures, which we have all seen and admired not only because of the tributes that the masters of one art have rendered to the masters of another; not only because of the historic association, which reminds us of the wonderful evolution and progress of medicine, nor because of the inspiration that they give to succeeding generations, but, even more, because of their symbolic significance; by the message that they bring to us from the torch-bearers of humanity, whose burden is to transfer the undying fire or progress from one generation to another. These historic pictures, in the light of this interpretation, suggest the familiar lines: " . . . . The torch: Be yours to hold it high. We shall not sleep, if ye break faith with us who die!"

The Evangel warns us: "As ye sow, so shall ye reap."

Professor Halsted died without offspring, but Nature, as if repentant for her unkindness, endowed him with a brain of prodigious fertility from which has sprung a numerous intellectual family of supermen. Dr. Halsted has given proof of his genius in many ways. He was great in his art. He was great in his science. He was great in his rare appreciation of the unity of the art and science of surgery and of the correlation of the medical sciences in general, which gave him a unique distinction as a teacher of surgery. He was great as the father and founder of a school of surgery which since its existence has stood unsurpassed in surgical scholarship, in surgical craft and in the attainment of surgical ideals and achievements. But in none of these was he greater than in the selection of the group of young men whom he chose to carry on his apostolate and to transmit his teachings.

"By their fruits shall ye know them," said the Evangelist, and by the seed of his culture and nurture the world now knows no richer harvest.

DR. WILLIAM S. HALSTED WITH PRESENT AND FORMER MEMBERS OF HIS STAFF AT THE TWENTY-FIFTH ANNIVERSARY OF THE OPENING OF THE JOHNS HOPKINS HOSPITAL, OCTOBER, 1914

Reading from left to right: Standing—Roy D. McClure, Hugh H. Young, Harvey Cushing, James F. Mitchell, Richard H. Follis, Robert T. Miller, Jr., John W. Churchman, George J. Heuer. *Sitting*—John M. T. Finney, William S. Halsted, Joseph C. Bloodgood.

As I recall the great attributes of mind so characteristic of our departed friend, and remember the singular elevation of his thought, I find him in notable harmony with Carlyle's brief sketch of man's place in the universe: "He is of the Earth, but his thoughts are with the stars. Mean and petty his wants and his desires, yet they serve a Soul exalted with grand and glorious aims—with immortal longings, with thoughts which sweep the heavens and wander through eternity. A pigmy standing on the outward crust of this small planet, his far reaching Spirit stretches outward to the Infinite, and there alone finds rest."

Sleep sweetly, tender heart, in peace!
Sleep, noble spirit, imperial soul,
While the stars burn, the moons increase,
And the great ages onward roll.

A Personal Appreciation of Dr. Halsted

By J. M. T. Finney

Now is the stately column broke,
The beacon's light is quenched in smoke,
The trumpet's silver sound is still,
The warder silent on the hill.

I CANNOT better preface my all too inadequate personal tribute to my former chief, that master surgeon, William Stewart Halsted, than by quoting these familiar words of Scott, because, in their changing metaphor, they express so well the commanding position of leadership in the field of scientific surgery held by him to commemorate whose life and work we are gathered here this afternoon. In his death, an irreparable loss has been sustained by the entire world of science.

I shall not attempt to appraise the real worth of Dr. Halsted's many contributions to the science and art of surgery, nor to designate the place that he has won for himself among the immortals in his chosen field of work. That will be left to others more competent than I to do justice to such a task. Mine will be simply to record my personal observations and impressions formed from a more or less close association with Dr. Halsted, dating from the day of the opening of the Johns Hopkins Hospital, May 7, 1889, to the time of his death, September 7, 1922, a period of over thirty-three years. Well do I remember our first meeting in the rotunda of the Hospital, crowded with the throng who had been attracted thither by the desire to see the new hospital and to hear the distinguished speakers who were to take part in the opening exercises. This brief interview, so characteristic of the man, representing so faithfully some of the individual traits that later his associates came to know so well, I shall venture, briefly, to describe. Dr. Welch very kindly took me under his wing, as he has so many other young men, and presented me to Dr. Halsted. After a brief exchange of courtesies, without a word of inquiry as to the character or extent of my training or fitness for the work required, "When can you report for duty," said Dr. Halsted. My part in the conversation need not be related here. Then, after a few commonplaces, and without further word as to just what was expected of me, he glanced at his watch, and upon the plea of another engagement, excused himself and was gone. My surprise and bewilderment may well be imagined. But from that moment, there was indelibly impressed upon my mind the fact that here was a

man most unusual and interesting, and in many respects unique. This impression, thus early formed, was strengthened and confirmed with each passing year.

It is a very difficult, indeed an impossible, task to attempt to describe the Dr. Halsted that we, his associates and students, knew. No one could do him justice. He was such a curious mixture of contradictions; abnormally shy, and sensitive as a woman; to a stranger, reserved to a degree; to his few intimates, the most charming of companions; endowed with a keen yet kindly sense of humor, and at the same time with a wit that upon occasion could be caustic in the extreme. He was the most modest of men. Caring little for the applause of the multitude, he preferred to be left undisturbed to follow the even tenor of his way; his mind intent upon the special problem that for the time being engaged his attention, yet ever alert to grasp new ones as they presented themselves. Of scholarly tastes and studious habits, one would not think of him as the athlete that he had been in his earlier years.

None would deprecate more than he the estimation, beyond their true worth, of his many contributions to the Medical Profession, to the World of Science and to Humanity. But bearing fully in mind his wishes in this regard, and with every intention of respecting them, I may be pardoned if upon this occasion I give voice to the desire of Dr. Halsted's former students and associates to record our appreciation of him personally and of what he has meant to us. We wish to pay tribute to him who was at once our teacher and guide, a constant stimulus to honest purpose and great endeavor. We like to think of him as a great figure in surgery, in many respects the greatest of his time, unique in the singleness of purpose that characterized his whole professional life, and in the effect that his example and teaching has had and will continue to have upon the lives of his students and associates so long as they shall live. Furthermore, it is only right that a permanent record should be made, for the information of future generations, of the high esteem in which Dr. Halsted was held by those who were privileged to work under him.

Can anything be finer than the ability to lead and shape the scientific thought and practice of his time in one's chosen profession, as Dr. Halsted did? Can anything be more satisfying than to be able, by his own original research, to add so much to the sum-total of human knowledge; to leave upon his students and associates the impress of his own personality, as he did; to found a distinctive school of surgery characterized by a meticulous observance of certain fundamental principles, more especially those that have to do with an improved aseptic technique, scientific thoroughness, the gentle handling of tissues, and the search after truth? It was granted to Dr. Halsted to accomplish all this and much more in the allotted lifetime of three score years and ten. What busy and fruitful years they were!

Let us for a moment enter a little more into detail with regard to some

of Dr. Halsted's personal characteristics as revealed to his associates. Reference has already been made to the fact that he was of an unusually shy and retiring nature. He shunned publicity and applause and shrank from everything that savored of notoriety. He did his best work in the quiet of his study or his laboratory, never before a crowded gallery, where he was always ill at ease. His apparent reticence, misinterpreted at times by some who did not know him, as coldness or lack of interest, was but a natural defence for his shyness. But let his attention be attracted by some phenomenon observed, or by some remark made in the course of conversation, and instantly the barriers were down. He at once became so much absorbed in the possibilities suggested by the thought just presented, that the shyness vanished and instead was revealed the interested scientist.

By birth and breeding as well as from natural inclination, Dr. Halsted was a cultured, courteous gentleman. An aristocrat, fastidious to a degree in his habits of life, of exquisite taste; a charming host, enjoying but not much given to indulgence in social pleasures, he was always a welcome addition to any company. The finer things in both nature and art appealed strongly to him. Along certain lines, he was a connoisseur, but in such a quiet way that none but his intimates knew that he had more than a passing interest in such things. In the all too rare moments when he allowed himself to unbend, he would converse most interestingly upon topics quite foreign to his life work. At such times, he showed the wide extent of his general information and revealed glimpses of that charming social side of his nature, the cultivation of which he appeared almost entirely to neglect. It was always a source of real regret to the members of his staff that, with few exceptions, it did not seem quite possible for him to establish with them that intimate personal relationship, so delightful to student and teacher alike. His younger associates felt keenly the loss of this comradeship, and Dr. Halsted himself was heard to remark upon more than one occasion, that he wished he knew how to get as close to the individual members of his staff as, for instance, Dr. Osler appeared to. It, however, was largely temperamental and, I believe, to a certain extent, artificial, this atmosphere of aloofness with which he surrounded himself. But he never seemed quite able to overcome it.

No chief ever had more loyal or devoted followers than were the members of Dr. Halsted's staff, and if their genuine affection for him was not more demonstratively manifested, it was simply because they felt that he preferred it so.

In the conduct of his clinic, Dr. Halsted was an ardent admirer and exponent of the best in the German School, in which he was trained. His students and assistants were not spoon-fed. His idea was to help a man to help himself, not to destroy his initiative by continually telling him what he should do next, and then showing him how to do it, but rather to leave him to follow largely his own lead, only helping him here and there, with a word of advice or

warning, as occasion required. The methods employed by him in organizing his clinic were at the time of the opening of the Johns Hopkins Hospital quite revolutionary. But the results achieved, during the years that have passed since that date, have amply justified his judgment.

Dr. Halsted's influence upon the group of younger surgeons trained by him was an unconscious rather than a conscious one. He taught by example, the best of all methods, rather than by precept. His associates were (much more than they realized) deeply impressed by his habits of thought and work. His enthusiasm, his painstaking accuracy, his close observation and his never-failing interest in studying problems with characteristic and indefatigable industry until he had at last mastered them, were most inspiring, and continued unabated to the very end. His methods were less striking than those of some of his confrères because less spectacular, but they did not suffer thereby in effectiveness. He left his impress upon all of his assistants who worked in his clinic long enough to appreciate the strength of his personality and the soundness of his methods. That this is so may readily be confirmed by a visit to those of the present-day clinics directed by men trained under him, of which there are a goodly number. It is a wonderful record that he has made, a record that appears partly upon the printed page, partly in the current surgical thought and practice, but more deeply still upon the hearts and minds, and is reflected in the actions of those fortunate enough to have come under his influence.

A man of comparatively few words himself, he was an excellent listener. He was a better writer than speaker, as he was a better surgeon than operator. As an original thinker, and investigator interested in the larger problems of scientific surgery, he was without a peer. As a contributor to surgical progress, no one was more active or fruitful. He was a stimulating teacher, although not always fully understood or appreciated by the student at the time. Perhaps the qualities that he most insisted upon in his students were accurate observation, careful record of facts observed, and correct reasoning from the data thus accumulated. He tried to make his students think, and think straight. He was not given to flattering his students and assistants, or complimenting them over much upon their achievements. He preferred rather to try to arouse in them the desire for knowledge, by exposing the extent of their ignorance. Particularly was this true in the case of any one who assumed knowledge that he did not possess. His students feared and respected his almost uncanny ability to ferret out what they did not know, and his habit of parading it before the class for their edification. Even the students, so disciplined, could not but admire the finesse with which it was done, and appreciate and benefit by it. "Faithful are the wounds of a friend." In this spirit, he worked for their good.

To those who were privileged to serve under Dr. Halsted and to observe at close range the way in which his mind worked and the characteristics which distinguished all of his actions, perhaps his earnest search

after and his passionate love of the truth were his most striking traits. Everything else was subordinated to this. It made no difference whether or not the truth, when finally discovered, confirmed or overthrew his preconceived ideas or previously enunciated theories. His absolute honesty made him always the first to call attention to his own mistakes. The painstaking care, however, with which his work was planned and the scientific accuracy with which it was performed made this rarely necessary.

His senses were so well trained that fancies were rarely mistaken for facts, and his logical and well trained mind readily coördinated the latter, and reached the proper conclusions with remarkable precision and dispatch.

To be a great teacher, to have the ability to impart knowledge or, what is of far more importance, to be able to instill into a pupil a thirst for it, to teach him proper habits of thought and work, to inspire him to search after truth until he finds it, let it lead him where it may, is indeed a great thing. Such a teacher was Dr. Halsted. His lectures and demonstrations, while often over the heads of many of the class, were an inspiration to the select few whose especial interest he commanded. To the good student, he was a great stimulus, to the poor one a constant terror.

The true investigator, the one to whom everything in nature presents a subject for research, is indeed a "rara avis." But this faculty may be stimulated and to a certain extent developed in students, by the proper teacher and the right kind of teaching. One of Dr. Halsted's most prominent characteristics was this rare and excellent faculty, namely, the ability to stimulate in his students their imagination and their curiosity, which are the essence of scientific research.

A man's success in his chosen field should be estimated, perhaps, by the scope and extent of his work; by the number of people that it touches and by the impress that it makes upon the thought and action of his time. Judged by this standard, Dr. Halsted ranks high in surgery. Few, if any, surgeons of his own or preceding generations have by their original contributions so enriched surgery, and in such varied ways. The versatility of his genius was quite as striking, perhaps, as its originality. While the science, rather than the art of surgery, appealed the more strongly to him, the latter was not wholly neglected, as witness the several valuable contributions that he has made in this particular field. Nevertheless, he should be classed as a head surgeon rather than a hand one. He was much more interested in thinking surgery than in doing it. He was happier in his laboratory than in the operating-room. He recognized and frequently referred to the fact in conversation with members of his staff, that operating was not his forte, and personally he was always glad to be relieved of its great responsibilities. Yet his associates will be able to recall many occasions when he has performed unusual and dangerous operations, requiring a high degree of courage and dexterity, with consummate skill. At such times, his thorough knowledge of anatomy and pathology were of great assistance.

L. Fortunato
1922
WILLIAM STEWART HALSTED
1852 - 1922

The belief was quite widespread among his younger associates, and especially the students, that Dr. Halsted secretly prided himself perhaps more upon his extensive and accurate knowledge of gross anatomy than upon anything else, although he would at times refer depreciatingly to the doubtful value to him of the amount of time that he had spent upon anatomy in his earlier days in New York. At any rate, the thorough fashion in which he used to quiz his students in this subject made a profound impression.

In preparing this brief and imperfect review of the more striking characteristics of him to whom we are gathered here this afternoon to do honor, the familiar lines of the poet Longfellow, "Lives of great men all remind us we may make our lives sublime," kept coming into my mind. They are, therefore, quoted here because they express the two ideas that are particularly emphasized in Dr. Halsted's career, namely, the elements of greatness in his work as seen by those most closely associated with him, and the sublimity of a life devoted to study and to the extension of knowledge.

Measured by all recognized professional standards, Dr. Halsted was a great surgeon, but he was more than this. He was a great scientist and a great humanitarian as well. No one man possesses in his character all of the elements of greatness. He would be a super-man. Each individual in varying proportion has his elements of strength and weakness. Such is human nature. Dr. Halsted was only human, and like all mortals, he possessed characteristics of both, which were quite evident to his friends and associates. But to those who were privileged to work under him long enough to come really to know him, and to the chosen few of his intimates who were permitted to enter the inner circle of his life, he will always stand out in memory as the commanding figure that he was, teacher, investigator, master-surgeon, benefactor of mankind.

In Memoriam—William Stewart Halsted

Address

By William H. Welch

I SHOULD like in behalf of all Dr. Halsted's friends here present to express to Dr. Matas our deep appreciation of the fine tribute to Dr. Halsted to which we have just listened. Those of us who know of the close personal and professional relationship between Dr. Halsted and Dr. Matas are aware that there is no one whom Dr. Halsted would have preferred to undertake an estimate of his life-work and surgical achievements, nor is there anyone more competent to do this than Dr. Matas.

There are a few thoughts with which I may occupy the short time remaining that have not been touched upon.

It is always interesting to consider a man's inheritance and early training in their bearing upon his future career. William Stewart Halsted came of sturdy English stock settled in Long Island by the middle of the seventeeth century, with a strain of old Knickerbocker blood. His father, a prominent dry-goods merchant, as well as his grandfather, had been trustees of the New York Hospital. Several collateral members of the family had entered the medical profession. His uncle, Thaddeus Halsted, was a well known and highly respected surgeon, for many years a surgeon to the New York Hospital, among whose publications it is interesting to note one relating to pulsating tumors of the thyroid gland.

William Halsted was prepared for college at Andover, and like many other Andover students of that day, was overprepared, a circumstance which does not tend to industry in the beginning of a college course. While not an assiduous student, he got much out of his college days at Yale, was well known and popular in his class, recognized as a fine and able fellow, interested and successful in athletics, being president at one time of the foot-ball association.

Those of his classmates who knew him well felt confident of his future success. He received his A.B. degree from Yale in 1874. As with many other college students his intellectual interests were first really aroused after he entered upon his professional studies. The best that one could get out of his studies at a medical college in those days was the work in the dissecting room, which was the only laboratory then existing in our American schools, and association with one of the more important teachers. In both respects Halsted was fortunate; he devoted much time to dissections and became early an assistant to the distinguished physiologist, Professor Dalton, the most stimulating and scientific teacher connected with the College of Physicians and Surgeons at that time. Through Dalton he became interested in reading Huxley's writings. Sands, the surgeon, was his preceptor. On graduation from the

College of Physicians and Surgeons in New York in 1877, he was awarded the first special examination prize, the highest scholastic honor at that time.

From the autumn of 1876 until the spring of 1878 Halsted was a surgical interne at Bellevue Hospital. No better hospital interneship was then to be found in this country. From this period date many observations and experiences, some original with him, which were of influence upon his later professional career. Frank Hamilton, Stephen Smith, Van Buren, Sands, Sabine were among those under whose surgical influence he came at this time.

So marked an impression had the young interne already made that he was chosen as resident physician to inaugurate the medical service of the New York Hospital in its new building on 15th Street, where he remained for six months and where I first met him on my return from Europe in 1878. During this service he devised temperature charts and introduced installations and methods, which have continued in use and were adopted elsewhere.

Delayed thus for six months in order to start the new service at the New York Hospital, which had been closed for several years, in October, 1878, he went abroad for two years of graduate study, his time being spent mostly in Vienna (two semesters), Würzburg and Leipzig. Nowhere else in the world at that time were to be found opportunities for study and research at all comparable to those of the German Universities, which were then the Mecca of aspiring students from all parts of the world. Here were opened the minds of many a student for the first time to the spirit of science and the methods and significance of scientific medicine. In full measure Halsted took advantage of these opportunities, received a great intellectual stimulus, and formed intimate associations, especially with some of the younger clinical and laboratory assistants, who afterward attained distinction. While perhaps his closest contacts were with the assistants in Billroth's clinic in Vienna, and he followed there and in other universities the work of the surgical clinics, even more of his time was given to work in anatomy, embryology, histology and pathology. He even succeeded in persuading the great psychiatrist and neurologist, Meynert, to give him a special course in the anatomy of the brain at six o'clock in the mornings. He was particularly intimate with Zuckerkandl and Wöffler, working with them on special problems. In Würzburg his time was spent mostly in Kölliker's anatomical institute, and in Leipzig in Cohnheim's institute working with Weigert, but also attending Thiersch's and Wagner's Clinics with occasional visits to Volkmann in Halle. His friendships with Mikulicz, v. Eiselsberg, Schede and above all Kocher were of later date.

During these student days in foreign lands Halsted interested himself in the life around him. He went to the opera and the theatre and was a member of a small dancing circle. He joined an eating club with some of the docents and assistants. During vacations he travelled, visiting Italy, Switzerland and France.

Altogether Halsted's two years of foreign study were an extremely stimulating and broadening experience

of permanent and fructifying influence upon his whole future professional life. He returned to America with a command of methods, with a broad foundation of knowledge, with an active spirit of inquiry and an enlarged outlook by no means limited to the field of surgery, where his future professional work was to lie.

Returning to New York in the fall of 1880 with nothing definite immediately in prospect, Halsted almost at once was offered a most exceptional opportunity,—that of assistant to his former college preceptor, Sands, the most brilliant surgeon of his day in New York, who shortly before had succeeded in having the entire continuous surgical service of Roosevelt Hospital placed in his hands. With a very large outside practice, not limited exclusively to surgery, Sands could give only a part of his time to the hospital service, so that no small portion of the operative work and of the care of surgical patients at Roosevelt Hospital fell into Halsted's hands.

The succeeding five years form a separate and distinct chapter in Halsted's life, unfamiliar to most of those who knew him only in Baltimore, a chapter in many ways so brilliant, so rich in accomplishment, in certain respects so different from that which followed at the Johns Hopkins that no just estimate of his qualities and life work is complete without giving it full consideration, for which of course this is not the occasion.

I knew Halsted well in those days of his highest physical and mental vigor, and saw much of him. He sent his students to take courses in histology and pathology in my laboratory at the Bellevue Hospital Medical School; he would collect tumors and other specimens from his practice which we would go over together at intervals of two or three weeks, and not infrequently I was a guest at the delightful little dinners where he and Dr. Thomas McBride gathered a few congenial friends at their house on East 25th Street. The memories of those days are to me dear and ineffaceable.

The rapid rise of Halsted as a teacher and a surgeon in the early eighties of the last century in New York was almost, if not quite, without precedent. In rapid succession he was appointed assistant demonstrator, then demonstrator of anatomy at the College of Physicians and Surgeons, assistant attending surgeon to Roosevelt Hospital, substitute attending surgeon to the Chambers Street Hospital, attending surgeon to Bellevue Hospital and to the Presbyterian Hospital, Surgeon-in-Chief to the Emigrant Hospital, and attending physician to Charity Hospital. He limited his practice exclusively to surgery, being perhaps the first to do so in New York. Although appointed physician to Charity Hospital, the surgical internes there, as in other hospitals, were eager to have him see their patients. Through pressure of other engagements his visits were made often at night, and so too not infrequently he met his classes in the evening. Of course he had taken on far more work than he should, but he was an indefatigable worker and very robust in health at this time. Within a year after his return from Europe he established the first dispensary at Roosevelt Hospital along lines original at the time and making a dis-

tinct contribution, now little remembered, to the history of out-patient services in this country. Here his Sunday morning demonstration classes soon became famous.

Halsted early in his New York career founded a quiz which soon developed into a genuine extramural school, the first of its kind in New York, with which were associated first George Monroe and Flint, later Hartley, Tuttle, Gilman Thompson and West Roosevelt. Soon it was found necessary to limit the number of students and only college graduates were received. All of the teachers had hospital or dispensary positions, utilized for clinical training of the students. No expense was spared in securing illustrative material of all sorts.

Halsted's students of those days would be amazed that there should be any question of his gifts as a teacher. It is true that after he came to Baltimore he abandoned completely the quiz or drillmaster type of teaching, but no one surpassed him in that line in those New York days, although even then he was fond of dwelling upon minute points, especially in anatomy. He knew his Gray, Hyrtl and Schwalbe as few have done. His students won most of the college prizes and far outstripped their competitors in the hospital examinations. The success of this extra-mural teaching was so great as to become something of a thorn in the flesh to the college by withdrawing so many of the best students from the lectures.

Halsted was the most talked-of of the younger surgeons of that period in New York, and many of the older ones shook their heads over his innovations. Among the younger generation there gathered around him a group of enthusiastic and devoted followers. His general reputation was that of a brilliant, daring and dexterous operator, but so repugnant were these epithets to him later, and so far removed were his surgical qualities from those of mere brilliancy and boldness and speed in operating, that I feel confident that his characteristic traits of thoroughness, carefulness in handling of tissue, safety, refined technique and deliberateness were his from the beginning.

Halsted returned from Europe thoroughly imbued with the principles inaugurated by Lister, which even at that time had found only limited acceptance in England and in America. He ranks among the first, if not the first, to develop in this country on the basis of these principles a consistent and thorough antiseptic technique which, when perfected in his hands in his clinic at the Johns Hopkins, constitutes one of his greatest contributions to surgery. Many of the features of this technique, as well as many of his surgical inventions, date from the New York period, to which also belong some notable scientific and practical contributions, as the refusion of blood in carbon-monoxide poisoning, the irrigation of the urinary passages with dilute sublimate solution under careful microscopical control of the bacterial flora, and above all the introduction of regional anesthesia of which we have heard from Dr. Matas. So confused had become the history of this last subject and so indifferent was Halsted to priority claims that the dentists, to whom neuroregional anesthesia by cocaine has been such an immense boon, ap-

pointed a committee to determine who deserved the credit of the discovery or invention, before awarding their gold medal to Halsted in April 1922. After some investigation they learned that Dr. Matas some years before had thoroughly sifted the matter and determined Halsted's title to the most important share in the discovery.

In 1885 Halsted's health broke down and there followed two to three years of severe and eventually triumphant struggle before he was able to resume continuously his work. In 1886 he came to Baltimore and began work in my laboratory, where with some interruptions he continued to carry on experimental investigations until the opening of the Johns Hopkins Hospital in 1889.

Halsted was one of that interesting group of workers, consisting among others of Councilman, Mall, Nuttall, Christian Herter, Meade Bolton, Flexner, Abbot, Brewer, Booker and Sternberg, who were associated with me in the two-storied pathological and bacteriological laboratory for the four years preceding the opening of the Johns Hopkins Hospital. Here he began his experimental work on the thyroid, on intestinal suture and on peritoneal infection. We were a happy and congenial little band of ardent workers, each sharing with the others interest in our scientific problems, Halsted's relations with Councilman and Mall being particularly intimate.

No greater good fortune could have befallen The Johns Hopkins Hospital and later the Medical School than to find Halsted here on the ground and available for the position of surgeon-in-chief to the Hospital and professor of surgery. While in these remarks I have tried to rescue from threatened oblivion and some misunderstanding some part of Halsted's early professional work in New York, it was here at the Johns Hopkins that he found his great opportunity, did his greatest work and established his undying fame.

Here Halsted first in America created a genuine school of surgery. He shares with Osler and Kelly the credit of organizing the clinical services according to a plan whereby it was rendered possible for the young resident surgeons and physicians, appointed on indefinite tenure, to be trained during long periods of time for the higher academic and professional careers. When one calls to mind the names and subsequent positions and reputation of the resident surgeons trained under Halsted, he realizes how notable has been this side of Halsted's work as teacher and leader of a school of surgery. He has repeatedly said that nothing has given him greater satisfaction than the consciousness that he has had a part in providing opportunities and in aiding the development of talented young surgeons. Critical of himself, he was also critical of others and extremely cautious in selecting those who were to serve on the upper resident staff, and fortunate in the extreme were those who attained these much sought positions.

While Halsted contributions to the technique and the operative procedures of surgery are of the first importance, he was much more than a mere operator and technician. He belongs to the small group of genuinely scientific surgeons, and was animated in high degree by the spirit of scientific inquiry. He always had his sur-

gical problems which, one after the other, absorbed his thought for the time being. These problems, many of broad biological interest, he attacked by laboratory and experimental methods, when they were not to be resolved by direct clinical observation. Leriche does not go too far in saying that Halsted was inspired by the spirit of Claude Bernard, that he was a biological thinker and developed surgery as an experimental science. Of his many honors, none was so significant a recognition of the scientific aspects of Halsted's work as his election to membership in the National Academy of Sciences, before which he presented one of his latest contributions.

Dr. Finney and Dr. Matas have spoken of some of the more important contributions of Halsted to surgery, and I shall make no further attempt to rehearse them now. Some of the qualities which make a man a leader, a founder of a school, the inspirer of a new movement or direction of thought or activity are not easy to define, for they are of a personal and spiritual nature. Personality comes first, for as Billroth has said in considering this subject: "The personal tradition counts for more than all the books." Those of his colleagues and pupils who were drawn closely to Halsted were fully conscious of the inspiration of a marked and uncommon personality. They recognized in him single-minded devotion to truth, a genuinely scientific attitude of mind, joy both in the search and in the discovery of new knowledge, a keenly critical sense, strength of character, high scientific and professional ideals, and delightful comradeship. The influence and the tradition of William Stewart Halsted as teacher, investigator and surgeon will remain a priceless possession of The Johns Hopkins University and Hospital, and an inspiration to his successors and to future generations of surgeons.

Studies in Experimental Epilepsy

By Walter E. Dandy and Robert Elman

From the Department of Surgery, the Johns Hopkins University

THE ready susceptibility of all animals to convulsions is shown by the fact that they can be produced experimentally in six general ways: (1) by anemia of the brain, (2) by asphyxia (venous engorgement) of the brain, (3) by traumatic stimulation of the central nervous system, (4) by chemical stimulation of the central nervous system, directly or through the vascular system, (5) by electrical stimulation of the central nervous system, directly or indirectly through the skin, (6) by injury to the brain followed by traumatic, chemical, or electrical stimulation, directly or indirectly applied.

ANEMIA AND HYPEREMIA

A splendid bibliography of experimental epilepsy is contained in an exhaustive article by Ito (1). From this we learn that as early as 1824 Kellie (2), and in 1826 Piorry (3), produced convulsions by bleeding animals; and that in 1824 Ashley Cooper (4) produced convulsions in dogs by depriving the brain of its blood supply through ligation of both internal carotid and both vertebral arteries. Practically the same experiments were repeated by Kussmaul and Tenner (5) (1857) on an extensive scale and with the same results. For reasons which need not now be considered, they concluded that the convulsions originated from stimulation of the medulla, to the exclusion of other parts of the central nervous system. This is probably among the first attempts to establish a "convulsive center"—an ever changing area in the hands of different investigators, who see fit to make overdrawn conclusions from insufficient or uncontrolled experiments. It is clear that from experiments so crude that the entire brain is deprived of its blood supply, conclusions of a specific nature are entirely unwarranted. Victor Horsley (6) long since called attention to the impossibility of placing any great value on these experiments. Leonard Hill (7) with great fortitude compressed one of his own common carotid arteries and a unilateral convulsion followed.

These experiments permit of one conclusion, i.e., that anemia of the brain causes convulsions, and from Hill's experiment on himself, it is safe to conclude that anemia of a cerebral hemisphere may cause convulsions which begin unilaterally. We have no right or reason to infer that cerebral anemia is the source of convulsions which occur in epilepsy. In fact, except in the sudden closure of cerebral vessels from emboli and thrombi, cerebral anemia probably plays no rôle in the production of convulsions, and subsequent convulsions resulting from these lesions are

due to the injured brain tracts rather than to any possible recurring anemia. The oft repeated explanation that local spasm of the cerebral arteries causes convulsions by producing anemia, is purely an assumption, for vasomotor nerves have never been demonstrated in the cerebral vessels. To quote Bayliss and Hill (8): " . . . . the cerebral vessels are free from any such control (vasomotor); the cerebral circulation passively follows the changes in the general circulation."

Landois (9) (1867) produced convulsions is young dogs by compression of the veins of the neck, the seizures being apparently similar to those brought on by Kussmaul and Tenner by excluding the arterial supply to the brain. Hermann and Escher (10) (1870) repeated Landois' experiments on cats and obtained similar results.

TRAUMATIC STIMULATION

Brown-Séquard (11) traumatized various parts of the nervous system in rabbits and induced convulsions. After section of the spinal cord, partial or complete, or the mere insertion of a needle into it, convulsions developed. Lesions of the medulla, the cerebral peduncles, the corpora quadrigemina, or even injuries of the popliteal or sciatic nerves, were sufficient to cause convulsions. At times convulsions developed spontaneously or from irritation of certain areas of skin which he termed "epileptogenous zones." At this early date, he noted that this epileptogenous zone and the convulsions were on the side contralateral to the lesion when the cerebral injury was in the cerebral peduncles or corpora quadrigemina. Attacks also developed after the cerebrum, cerebellum, and brain-stem had been removed. It was Brown-Séquard's view that epilepsy followed from the loss of control of the base of the brain, "principally the medulla," over the excitable reflexes of the cerebrospinal axis. Owing to his prominence, his opinions on epilepsy obtained great weight. Apparently, his views never changed. Many years later, the great Hughlings Jackson (12), whose views were so widely at variance, found Brown-Séquard's opinions on epilepsy still holding sway.

Westphal (1871) (13) showed that convulsions identical with those of Brown-Séquard could be produced in rabbits by lightly striking the head. The convulsions appeared immediately after the trauma, or within a few seconds, and continued over a period of weeks and even months.

Rabbits are very susceptible to convulsions, so much so that the most trivial injury to the brain, even to a peripheral nerve, is a sufficient stimulus. This objection makes it difficult to accept any finely drawn conclusions. Nothnagel (14) (1868) produced small focal lesions in the pons. The convulsions which followed were interpreted to be due to stimulation of a convulsive center. He even postulated the seizures to be the result of stimulation of two independent centers situated nearly in apposition—(1) the convulsive center and (2) the vasomotor center, the latter effect causing coma. Binswanger (15) (1886) repeated Nothnagel's experiments and doubted their value as interpreted in human epilepsy. He thought epilepsy to be the result

of stimulation of "motor tracts" and not of any center.

CONVULSIONS FROM CHEMICAL STIMULATION

Convulsions due to convulsant drugs are known to all students of pharmacology. Various drugs have been used, among the most effective being absinthe, picrotoxin, cinchonidin, and acid fuchsin. Of these drugs, absinthe has probably been most widely used. There is some question whether it may act only on the brain and not on the spinal cord. First used by Morcé (16) (1864), developed into popular use by Magnan (17) (1876), it became the method of choice of inducing convulsions by the great masters, Hughlings Jackson and Victor Horsley. It was their opinion that the convulsions resulting from absinthe more nearly simulated those of epilepsy than those produced in any other way. Although Horsley thought absinthe did not act upon the spinal cord, for after cutting the cord convulsions did not result, Magnan (18) performed the same experiments and convulsions followed. One of the most interesting features of convulsions was disclosed by Horsley (1885) when he showed that the convulsions following absinthe were clonic or tonic, the former depending on the participation of the cerebral cortex and the latter on its absence. Ziehen (19) (1886) also showed that when the cerebral cortex was removed the clonic element of the convulsions disappeared, leaving a tonic spasm. Hill (20) (1900) demonstrated that by shutting off the cerebral circulation after absinthe injection, the convulsions would be transformed at once from clonic to tonic form. From a series of clinical and pathological observations, Hughlings Jackson (21) (1877) had long since made these deductions and the experiments of Horsley were undertaken to test them.

FOCAL CHEMICAL STIMULATION OF THE BRAIN

The use of chemicals as local irritants has been largely confined to the cerebral hemispheres. It probably followed the use of electrical stimulation. Landois (22) (1887) spread kreatin and urinary products over the surface of the brain; Bickel (23) (1898) used bile pigments; Korángi and Tanszk (24) (1890) Liebig's meat extract; and convulsions readily followed all such procedures. Lapynsky (25) (1899) treated the medulla of frogs with urinary products and convulsions followed. The theory that epilepsy was due to auto-intoxication accounted for the stimulants used and acquired considerable support from the results obtained. Pierre Marie (26) (1887) was one of the most ardent exponents of this theory.

By placing on the motor cortex a piece of filter paper saturated with strychnia (a method previously described by Baglioni and Amantea (27) (1914)), Amantea (28) (1921) produced focalized convulsions. Following cauterization of the cortex, the same stimulation did not induce convulsions. He found sensitive areas of the skin corresponding to the injured motor area involved, and by light irritation of these skin areas convulsions could be induced at will. These findings correspond closely with those of Brown-Séquard.

ELECTRICAL STIMULATION OF THE BRAIN

The galvanic stimulation experiments of the cerebral cortex of Fritsch and Hitzig (29) (1870) and of Ferrier (30) (1873), which made the greatest contribution of all time to cerebral localization, have also added much to our knowledge of epilepsy. That focal convulsions could be produced in this way was merely a verification of predictions by Hughlings Jackson, who had made such a careful clinical and pathological study of epilepsy. This method was soon to be used as a means of accurate identification of cortical areas in the human brain at operation by Victor Horsley—and with results which were precisely those of animal experimentation.

Munk (31) (1881) showed that convulsions can be produced by stimulation of parts of the cerebral cortex other than the motor area, but that a higher dosage is required.

CONVULSIONS RESULTING AFTER EXPERIMENTAL CEREBRAL DEFECTS ALONE

Luciani (32) (1878) induced spontaneous epilepsy in dogs by excision of the motor cortex. The convulsions, however, did not develop at once, but some time later, the time interval varying between a few days and several months, and began in the side contralateral to the cerebral lesion. In a monkey the seizures developed three days after the motor cortex was excised. The interval between the cortical insult and the onset of convulsions varied from a few days to one and one-half years. The attacks gradually increased in frequency and severity and all but 2 of over 50 dogs and cats so operated upon died in status epilepticus. As the result of his experiments, Luciani thought convulsions were of cortical origin—a view which must always go back to Hughlings Jackson for its origin. Vulpian (33) (1885), conducting similar experiments, obtained the same results.

The well-known extensive cerebral extirpation experiments of Goltz (34) (1892) also yielded spontaneous convulsions after the operations, the dogs usually dying in status epilepticus several months later. Convulsions were not restricted to those cases in which the motor cortex was injured, but occurred after artificial defects of the occipital lobe, the temporal lobe, in fact, of nearly any part of the cerebral hemispheres. He looked upon convulsions as a disturbance of a very labile balance of the nervous system and as induced by an injured brain. It should be noted in this connection that Ito was unable to observe spontaneous convulsions in a large series of animals in which he had introduced foreign bodies extradurally. This was a cause of great concern to him in view of the results of Luciani and Goltz. Possibly the extradural situation of the foreign body may account for the difference.

Laborde (35) (1891) demonstrated 2 frogs before the Biological Society of Paris in each of which spontaneous convulsions had followed an injury to the brain; in one the removal of a large part of the forebrain, and in the other a mere needle prick of the corpora restiformia. Convulsions could also be induced at will by gently rubbing the skin.

Thomas (36) (1921) pricked the brain of frogs with a needle and convulsions followed injections of subnormal doses of acid fuchsin as readily as when extensive destructions of the brain were made. The results of these experiments were verified by Syz (37) (1923).

CONVULSIONS RESULTING FROM CEREBRAL INJURY PLUS STIMULATION

Abel (1910), several hours after a class demonstration in which a frog's forebrain had been stabbed, found the animal in convulsions. This accidental finding impressed Dr. Abel and stimulated one of the most far-reaching and fundamental studies on convulsions (Barbour and Abel (38) (1910)). These authors demonstrated that, following injury to the brain of frogs, convulsions can be readily induced by (*a*) fatigue, (*b*) cold, and (*c*) much smaller doses of acid fuchsin than are required to send into convulsions a frog with an intact brain. Abel (39) (1912) later observed that the injured central nervous system stained a deep pink after acid fuchsin injections, whereas the normal brain remained uncolored in a similar experiment. Syz (37) repeated these experiments with identical results and concludes that in some unexplained way injury to the brain causes an increased absorption of the dye into the entire central nervous system—a conclusion which, if substantiated, will be of great significance in the etiology of epilepsy.

Sauerbruch (40) (1913) obtained results in monkeys and rabbits very similar to those of Abel, and of Barbour and Abel, in frogs. Following a puncture of the motor cortex, or painting the motor cortex with iodine, or the intracerebral implantation of a foreign body, the animals were studied over periods of two to eight months, injections of small amounts of cocaine being used to stimulate convulsions. It required only one-fifth of the normal convulsive dose to provoke convulsions in these animals.

It should be noted in passing that Munk (31), working in Horsley's laboratory, was unable to obtain convulsions after absinthe injections, if the cortex was quickly removed. Tsutschaninow's (41) (1894) results after santonin poisoning, and Cobb's (42) (1922) after thujone injections, were essentially similar. Cobb found that decerebrated animals required 2 or 3 times the intravenous dose of thujone necessary to produce convulsions in an animal with an intact brain, but that the convulsions are similar. These latter results—i.e., from the acute stage of cerebral injury—are hardly applicable to the attacks in epilepsy, for only the attacks which occur at a later period when the initial defect has healed, are analogous to the convulsions of human epilepsy. They do, however, indicate that the motor tracts of the cerebral hemispheres are more sensitive to systemic toxic stimuli than are the motor tracts in the brain-stem.

The purpose of this communication is to present certain experimental data indicating the importance of defects of the brain in the development of convulsions. It is only fair to state that these experiments were sugested by certain impressions which had been drawn from an analysis of the histories of patients afflicted with epilepsy, from a series of operations on the brains

of epileptics, and from a post-mortem study of epileptic brains. Briefly summarized, it appeared from these studies that in most of the cases of epilepsy there were positive evidences of cerebral lesions, which were considered to be the cause of the convulsions. There was nothing specific or uniform about the cerebral lesions; probably the greatest number were congenital maldevelopments or malformations of various kinds; many were acquired defects of vascular, traumatic, or inflammatory origin, and many others were neoplasms and inflammatory new growths (43). Some lesions were diffuse, others were focal. These studies indicated that, although the individual expression of convulsions may vary greatly, they are all fundamentally similar, in that there is an underlying cerebral lesion which in some way lowers the threshold at which convulsions develop.

The accompanying experiments were undertaken to determine if localized traumatic injuries of the brain actually render the animal more susceptible to convulsions, and to learn if, in a general way, the location of the injury is important in their production. These experiments are intended only to determine a principle and they merely scratch the surface of the details of this vast problem.

To bear any trustworthy analogy with human epilepsy, the animals must be tested, not at the time the cerebral defect is produced, but at a later date when healing of the primary lesion has taken place. For epilepsy is a chronic ailment which develops long after the initial injury to the brain.

Nearly all animals are subject to spontaneous convulsions which presumably are analogous to the human convulsions in epilepsy. This is true not only among mammals—dogs, cats, horses, cows, sheep, rabbits, etc.—but also among lower forms—birds, frogs, and others. To interpret experimental convulsions in terms of human epilepsy, it must be possible to produce them at will by artificial stimuli which can be measured. Fortunately, this can be done. Convulsions can be induced at will in any normal animal, just as in a human being, by electrical or chemical stimuli. It then remains to be determined if the measurable amount of these stimuli necessary to induce convulsions—the epileptic reserve—is altered after lesions of the brain have been well healed.

A study of the various experimental methods employed resulted in our adoption of the absinthe method—the old method of Hughlings Jackson and Victor Horsley—as the procedure of choice. These observers considered absinthe to have a fairly specific action on the cerebral cortex. Our experiments add a degree of support to this viewpoint. It is difficult to believe this action is exclusively limited to this part of the brain.

Cats have been used in all of these experiments. A 10 per cent emulsion of wormwood oil in acacia and water was administered through the stomach tube. In order that absorption of the poison might be uniform, the animals were deprived of food for twelve hours. We have chosen an emulsion of wormwood oil (absinthe being the active principle) rather than an alcoholic extract of absinthe in order to avoid any possible misinterpretation through the effects of the alcohol. It is quite probable,

TABLE I

ANIMAL NUMBER	LOCATION OF LESION	DOSE PER KILOGRAM OF BODY WEIGHT																
		1 cc.	1.5 cc.	2 cc.	2.5 cc.	3 cc.	3.5 cc.	4 cc.	4.5 cc.	5 cc.	5.5 cc.	6 cc.	6.5 cc.	7 cc.	7.5 cc.	8 cc.	8.5 cc.	9 cc.	9.5 cc.
F 2	Motor cortex				+ 12														
F 4	Motor cortex				+ 4														
F 5	Motor cortex				+ 13*		+ 12												
F 6	Motor cortex		0 8	0 4	+ 16	+ 15	0 12			++‡3†									
F 7	Motor cortex		0 5		+ 8														
					+ 4														
F 9	Motor cortex		+ 4		+ 3														
K 1	Motor cortex	+ 12	0 6	+ 8	+ 7														
K 3	Motor cortex	+ 8	+ 6	0 5	+ 4														
K 5	Motor cortex			+ 4															
F12	Occipital cortex				0 4	0 5			+ 7‡										
F13	Occipital cortex				0 4		0 7	0 20		+ 8									
F11	Occipital cortex				+ 4§		+ 20	+ 12											
F14	Cerebellar cortex				0 4				0 10		+ 16								
F15	Cerebellar cortex							+ 4											
Normal 1														+					
Normal 2														0					
Normal 3																			†+
Normal 4																		+	
Normal 5																	+		
Normal 6													0			+			
Normal 7																+			
Normal 8																+			
Normal 9																	+		

Key to table: + = convulsion; 0 = no convulsion; numbers 4, 6, 8, etc. = weeks after operation.

* Death from convulsions. Dose 2.5 cc. per kilogram of body weight.

† Status epilepticus with recovery.

‡ Momentary attack two hours after administration of drug.

§ Animal pregnant.

however, that the intravenous injections of thujone, as used by Cook, may prove superior.

The dose of the drug has been given according to the animal's weight, and the results are so recorded in Table I. The lesions produced in the brain have been simple extirpations of the cortex and subcortex over the Rolandic area, the occipital lobe, and the cerebellum. In some experiments a simple incision has been made into the brain and in others a small foreign body has been imbedded below the cortex. The absinthe was given several weeks (four to twenty) after the cerebral injury had been inflicted. The reason for this interval of time was to simulate more nearly the conditions in human epilepsy where the intracerebral lesion is one of months' or years' duration, i.e., where the convulsions develop after the original lesion in the brain has well healed.

SUMMARY AND CONCLUSIONS

The most striking fact contained in these experiments is that one-third to one-seventh of the dose of absinthe required to produce convulsions in normal cats will incite attacks when the motor cortex has been injured several weeks previously. The experiments show conclusively that injury to the cerebellar and occipital lobes is far less effective in making the animal susceptible to convulsions, than is injury to the motor cortex. They also suggest that less absinthe is required to induce convulsions in occipital and cerebellar injuries than in the normal, but since there is some variation of the convulsive dose in normal animals, and from time to time even in the same animal, we are not willing, with the limited evidence at hand, to draw a positive conclusion in these cases.

When the minimal convulsive dose is given to an animal with injured motor cortex, unilateral convulsions will develop, and without loss of consciousness. These are comparable to petit mal attacks in human epilepsy. They are not so focal as those seen in human beings; they are evident as a turning of the body in circles, but always in the same direction. If the left motor cortex is removed, the animal will rotate clockwise; if the right motor cortex is affected, the direction of the circles will be counter-clockwise. Either these unilateral manifestations may terminate without further involvement, or they may pass over into a general convulsion. If the stimulant is of just the right dosage, the seizure remains more or less focal (petit mal), but any increase in the stimulant quickly causes a general convulsion. The inference to be drawn from these observations is that the injured area is the vulnerable point—*locus minoris resistentiae*—which is attacked by the convulsant drug. Another fact which we have observed is the difference in the character of onset of convulsions in cats with motor injury, and those of normal cats. In the normal cats pronounced restlessness and irritability precede a convulsion, as if the whole nervous system were affected by the drug and the convulsions were only a part of this general process. But in cats with healed motor defects, this preliminary irritability does not appear, the convulsions suddenly developing without warning in a placid and normally composed animal. The probable

reason for this difference is that the dose of absinthe which causes convulsions in an animal with a motor defect, is far less than the dose necessary to produce general changes in the nervous system. The same difference was observed when the occipital lobe was injured.

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Dr. Halsted's Friday Clinics

By Mont R. Reid

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DOCTOR HALSTED prepared for his Friday clinics with a thoroughness that only a few of his pupils have ever realized. Those of us who had the rare privilege of assisting him and his secretaries know the amount of work he devoted to the subjects he wished to bring forward.

It was his wont to present historical facts and fundamental surgical principles of the greatest value. It may be true that for the general run of his hearers this knowledge was highly technical and of fleeting interest; nevertheless, I have no patience with those who have said that for this reason he was not a good teacher of medical students. The fact is that his conception of teaching was different from that of most men. He believed in inspiration, not drilling. By his insistence upon fundamental principles, by his thoroughness and unfeigned joy in searchings of the literature, he wished to give the students a proper viewpoint—an important factor in medical education, although often overlooked. We cannot estimate the value to medical students of the example set by this brilliant teacher. They all admired him and it is not a very long step from admiration to emulation. I believe it is due largely to the influence of such teachers as Halsted and Mall that medical students have gone out from the Johns Hopkins University and have continued to develop so satisfactorily all over the country.

Dr. Halsted never postponed a new idea or a new observation because he was in the act of giving a clinic. Rather, he embraced the opportunities for thinking and seeing in the presence of his students and pupils. It was not unusual for him to digress for a while in order to discuss with his Resident some new idea or new point of view. And in these clinics of his were noted observations or were born new ideas that led to many important clinical or experimental studies reported in the surgical literature either by himself or his pupils.

His pupils, residents and members of his staff, attended his clinics year after year with increasing interest and profit, and regrets were often expressed that what he said could not in some way be preserved. More especially was this lack felt when, as so frequently happened, he recounted personal reminiscences of great value and interest, not obtainable from the medical literature.

During the school year of 1920–1921 my secretary attended Dr. Halsted's clinics, without his knowledge, and took them down as best she

could. Their nature, and the manner in which he presented them, made a verbatim copy almost impossible. However, the clinics for that year, although in a somewhat fragmentary form, are among the cherished possessions of his gifts to me.

It has been difficult to select one or more clinics for this memorial number of the Bulletin. The two chosen are presented here because they were responsible for the inspiration that led to his last experimental work. Many of you will recall his classic clinics on wounds and wound healing, osteomyelitis, goiter, breast cancer, intestinal anastomosis, common duct surgery, aneurysms, drainage, herniae and many other subjects. The following excerpt is taken from his clinic on exophthalmic goiter. It illustrates the keen sense of humor, the fine sense of scientific honesty, and the delightful reminiscences in which were combined instruction and entertainment.

"When Dr. Welch first saw a section from the hypertrophied thyroid of a dog, he did not know what it was. That was not his fault, of course. I took some specimens to Germany with me in 1896 and showed them to Wölfler and others. They did not know what they were and I would not tell them at first. I took them to Kocher in Berne, and he did not know what they were. So you can imagine how very interesting those times were. When we were working in the laboratory here we showed our specimens to Sir Victor Horsley, who was visiting in America at that time. He thought them remarkable and grasped their significance at once. For a day or two he spent much time in the laboratory looking at the specimens. We thought, of course, that the condition had never been discovered before, but I found out some six months afterwards that he had noticed this hypertrophy after excision of the thyroid gland and had had actual pictures of it in the Lancet in 1886; so naturally I wrote to him. He (Horsley) said that he had not been willing to take the glim off my enthusiasm. Later, I was still more impressed when he held up one of his own papers for some months in order to refer to my work. I published my article on the thyroid gland in dogs in the first volume of the *John Hopkins Hospital Reports*, in 1896. In the meantime Horsley wrote me about it, saying that he was contributing to *Virchow's Festchrift*, but did not like to hand in his article without referring to my publication on the thyroid."

DR. HALSTED'S CLINIC, OCTOBER 1, 1920

Subject: The importance of a balance between the arterial, venous and lymphatic systems. The bearing of infection on many cases of edema.

"To illustrate the subject I want to talk about, Dr. Reid will give the history of the patient before you."

The patient, a boy twenty-three years old, was treated in this clinic at the age of six for tuberculous glands in the right groin. At the time of his admission there were numerous discharging sinuses which connected with each other by small channels running under the skin. Dr. Finney operated upon him, removing the glands of the groin and a considerable amount of skin in order to excise the sinuses and, in addition, a good many glands along the iliac vessels. In order to get at these latter glands Poupart's ligament was lifted up but not divided. There were no complications

following the operation. The patient stayed in the hospital for several weeks, the wound healing by granulation.

After this operation he was perfectly well for five years; then his leg suddenly became so enormously swollen that he had to stay in bed for about two months. He was nauseated and vomited, and was delirious most of the time. The leg became bluish, or as he expressed it, "turned all kinds of colors." The swelling finally subsided to a great extent but the leg has never been normal since. After he began to get about, it became markedly swollen and has remained so to such an extent that he has not been able to work steadily at anything. After he has been on his feet for any length of time it swells and pains him. Since this first attack he has had two others which were quite severe, the last one three years ago. In each of these his illness began with nausea and vomiting followed by delirium, and the leg became so markedly swollen that it seemed as if it would burst. Besides these three severe ones he has had a few minor attacks of pain and swelling, but they were not associated with nausea, vomiting and fever.

During the past summer he has been treated by an osteopath who, he thinks, has helped him a great deal. I saw the boy, however, about a year ago and I do not see any noticeable change in the condition of his leg.

DR. HALSTED: "You will see that the case is one of marked swelling of the right leg without any discoloration. There are numerous abrasions, and from these a large amount of fluid has exuded at times. There is some edema, but the condition is largely one of connective-tissue hypertrophy due to a long-standing chronic edema."

"*Question 1:* What causes edema of the leg?"

Student: "In a general sort of a way the edema of the leg is due to some disturbance of the normal lymph flow."

"Your answer is very good and true, but of a very general nature."

"*Question 2:* Do you think that excision of the inguinal glands alone would cause edema of the leg?"

Student: "No."

"That is quite correct."

"*Question 3:* Then, what does cause it?"

Student: "Probably the operation along the iliac vessels together with a superimposed infection have been sufficient to block the lymphatics and thus cause edema."

"In this connection I am reminded of the case of a patient upon whom I operated some thirty years ago in New York. At that time I excised the inguinal glands on both sides. It was early in my career and I was much worried and mortified when an edema of the scrotum developed. This was perfectly enormous and I consulted many surgeons in New York about it. Nothing, however, seemed to do any good, and I more or less lost track of the patient, but never forgot him. Within the last two or three years this patient showed up in Baltimore for an entirely different condition, and at first I did not recognize him. When he reminded me of what I had done for him, I immediately recognized and examined him, for I had never forgotten the anxiety that he had caused me. Although a little edema of the scrotum persisted, the condition had largely disappeared, but it was interesting to know that during these twenty-five or thirty years he had had numerous attacks of nausea and chilly sensations followed by an immediate increase in the size of the scrotum.

"Another case which came under our care last spring and in which Dr. Reid

operated is interesting. This patient was a woman about forty-five years of age, upon whom I had operated some four or five years previously for carcinoma of the breast. She had been perfectly well until four or five weeks before coming to the hospital, when she developed rather suddenly an enormous edema of the arm and hand. She says the skin of the arm became so tight that she thought it would burst and that the hand looked almost like a boxing-glove and was very painful. The arm continued swollen but the discoloration gradually disappeared and by the time she came to the hospital the edema had already subsided considerably.

"On examination there was a little puckering of the skin of the axilla right at the junction of the graft with the old skin. At operation Dr. Reid found that the vein was completely occluded, mainly by compression from without. The vein was excised and the recurrence removed, the wound being covered by a plastic operation. The edema of the arm began to subside much more rapidly and at the time she left the hospital, three weeks after the operation, it had disappeared entirely.

"Another interesting case was that of a woman upon whom we did a breast operation some twenty years ago and who for a great many years had attacks of edema of the arm associated with fever and chills. The arm would become very tense but never suppurated.

"These cases are extremely interesting and their etiology certainly has a fundamental bearing on the subject of edema. The mechanical obstruction alone is in most cases certainly not an important factor. We see this illustrated very definitely in our breast cases where, without infection, we never see edema of the arm. In these, however, we remove all the glands and certainly interfere to a most marked degree with the lymph channels. When, however, infection occurs, it is the rule for edema to occur.

"*Question 4:* How do you explain that?"

Student: "The infection must cause a reaction which interferes to a greater extent with the lymph drainage."

"That is very good. One does not need any marked infection in order to get this result. When the skin edges in a breast case are sutured down too tightly and a little marginal necrosis develops, we are very much worried, for this slight necrosis is often sufficient encouragement to an infection which may lead to a persistent edema of the arm.

"In this connection I recall the name of Carnochan. He practised in New York a few years before my day and was really a very famous surgeon at that time. He was the first man to do a complete resection of the lower jaw but, besides this, he operated for chronic edema of the leg. His operation consisted in a ligation of the femoral artery. The edema of the leg practically disappeared. This case, although reported, has probably been overlooked by a great many people, but is undoubtedly one of fundamental importance.

"It seems as if a balance between the arterial, venous and lymphatic systems certainly must be maintained, for a disturbance of this balance is liable to lead to trouble. By this

operation of ligation of the artery, the balance between these systems in the leg was probably reestablished. This question of balance has been brought out very well, I think, in connection with the vascular system, during the recent war. It came to be well nigh the universal opinion among surgeons that, when one had to ligate a main artery for war wounds, it was probably safer to ligate also the corresponding main vein. In fact, in most of the armies, including the German, it was, I think , an order to ligate, in cases of arterio-venous fistula, both the artery and the vein above and below the point of the fistula. The results in these cases with such treatment were very much better, and gangrene resulted much less frequently than when the artery alone was ligated.

"Throughout the writings of the various war surgeons, I saw no mention of a most interesting case which was reported many years prior to the war, but which was evidently overlooked by most of the people writing on the subject. Von Oppel was working in St. Petersburg when a case of arterio-venous aneurysm between the axillary vessels came under his care. He operated on the man in the morning about 10 o'clock and ligated the artery above and below the fistula, but did not disturb the vein. After the operation the patient's hand and arm became cold and blanched, and it was felt certain by 2 or 3 o'clock in the afternoon that the arm would die. He then operated again, thinking there might be some compression or trouble at the site of the first operation. Immediately after this second operation the hand for a few minutes seemed to become much better in color and von Oppel was much encouraged. It, however, became cold and blanched again and he became convinced that something else had to be done. He watched this patient constantly from 10 o'clock in the morning until eight o'clock in the evening, and then performed a third operation, at which he ligated many veins around the site of the fistula including almost certainly the axillary vein. Immediately after this operation the circulation in the hand improved and its capillary pressure rose several millimeters. From that time on the patient did no trouble and made an uneventful recovery.

"This is a fine case both from the standpoint of the interest and watchfulness of the operator for his patient, and also from the standpoint of a balance between the arterial and venous systems.

"Whether or not in cases of arterio-venous fistulae it is better to ligate both artery and vein above and below the fistula or to divide the fistula and restore the lumina of the vessels is probably still a question. I should be inclined to think that, where feasible and possible, it is better to restore both vessels. Recently Matas reported a very interesting case of arterio-venous fistula between the subclavian vessels. He did his operation under novocaine—and it was really a wonderful operation. He is a very prolific writer and it required three numbers of the *Journal of the American Medical Association* to report this case. The artery was ligated on both sides of the fistula; the vein, however, was restored. The patient developed a small area of gangrene

of the hand—I wonder if it would have occurred had the vein, too, been ligated.

"I am not prepared to go so far as to say that when a large artery is ligated the vein also should be ligated. It probably would be safer, I think, to occlude the vein with a device like the metallic band which, if necessary, could be removed. In the case before you it is very likely that the external iliac artery should be occluded either partially or completely by means of a band. Then, if unlooked-for disturbances resulted, the band could be either removed or another one applied to the vein. In this instance I think we will apply a band.

"The whole question of a balance between the vascular and lymphatic systems is complex and one that needs a great deal of study. The edemas following operation are due to disturbances in this balance. In many of the cases of recurrent attacks of edema associated with nausea and vomiting and general disturbance, infection certainly plays a most important rôle."

Almost immediately after this clinic Dr. Halsted began his experimental work on the replantation of limbs in dogs and on the subject of edema in general. The results of these experiments have been partially published by Halsted, Reichert and myself.

He went into this work with his usual interest and thoroughness, and a few weeks later, when a case of elephantiasis came into his clinic for surgical treatment, he gave another clinic on the same subject.

DR. HALSTED'S CLINIC, OCTOBER 22, 1920

Question: "Miss B. What kinds of elephantiasis have we?"

Student: "The infectious variety, the kind following operation and the kind associated with filaria."

Question: "Why should elephantiasis follow operation?"

Student: "I suppose from obstruction of the lymph channels."

DR. HALSTED: "Very well. We also have the congenital form. The non-endemic form is usually not associated with filaria, and is the commonest form of elephantiasis in this country.

"Now what has been done here, Miss B.?" (Refers to the elephantiasis patient in the room.)

Student: "The leg has been bandaged and she has been kept in bed for several weeks."

DR. HALSTED: "The skin also is being brought into proper condition for an operation. Already there is a marked difference in the leg since her admission; the inflammation is less and the leg is not so tense. Until recently, the horizontal posture, bandages, etc. were generally used, but the results of these procedures were only temporary. Do you know anything else that has been done?"

Student: "One can take out a long strip of fascia."

Dr. Halsted: "What is the object of that operation?"

Student: "To start the lymph drainage."

DR. HALSTED: "The first operation done which promised success was performed by Carnochan of New York. He was a man of great literary tastes, and altogether unusual. He was a surgeon not of a type ordinarily seen. This is his original paper which none of you would be likely to see. It was published in a New York journal which no longer exists.

"In the first case that he treated, he ligated the femoral artery. The result of this operation was very successful. Several others were successful to a less degree. He made an observation which was most interesting, namely, that the femoral artery was dilated and the external iliac small; the two communicated freely. That is a remarkable observation. Furthermore, he makes the statement that in elephantiasis the femoral artery is well known to be dilated. Whether this be true or not, I do not know. I have always had in mind the effect of constriction of the artery in these cases—so that is something about which to know and something to watch for. In the cases of elephantiasis we should determine whether the femoral artery is really dilated.

"Professor Fischer, of Utrecht, in 1869, published a paper in which he collected all the cases of ligation of the femoral artery for elephantiasis of the leg. He gives a series of 21 cases. There were a few deaths, two or three, from secondary hemorrhage. At that time every surgeon might expect to have some secondary hemorrhages. There were quite a number of temporary cures, but by degrees this operation was given up. It is interesting that there should have been this long gap between Fischer's and the Kondoléon operation. Many men had contributed little grains which led to this operation. The first definite one was by Handley in 1908 who advised and tried with success the subcutaneous drainage with a thread led through the tissues. Large quantities of fluid were picked up along this string. This suggested its use for the swollen arm after the breast operation. I was very anxious to try it and wrote to Handley about it twice. In his reply he said that he had been so occupied with other things that he had lost interest but, in answer to my question, would say that he considered the operation a failure. Of course his must have been a failure. His idea was, however, a good one primarily; he established some sort of drainage, and one author credits him with the idea that he in some way might have established a communication between the lymphatics."

Dr. Halsted: "Can you tell what would happen to a drain put in subcutaneously with that object in view?"

Student: "In the first place it would become infected and the tissues would slough out."

Dr. Halsted: "What happens around every drainage tube?"

Student: "It becomes walled off."

Dr. Halsted: "The same thing happens to the string. Infection intensifies the walled-off region around the thread.

"There were other procedures which finally led to the Kondoléon operation. Lanz, one of Kocher's assistants, in Berne, thought it necessary to do something more radical than Kocher was doing. He incised the deep fascia and carried strips of fascia down through it into the muscles. Others then used strips of subcutaneous tissue and fat—all with some success. Others, too, before the time of Kondoléon, had excised a piece of skin and fascia, sometimes very large, in the hope of bringing about better drainage, but, finally, without going further into details, this operation of Kondoléon was developed.

"There are a good many papers on the surgical treatment of elephantiasis. The best one in English on the whole

subject from a surgeon's point of view is by Matas. We have it here in the *American Journal of Tropical Diseases*, July, 1913. It is a long paper, beautifully written. His exposition is very clear and I would advise all of you to read it. He gives a diagram to show just what Rosanow did with flaps of fascia around the muscle.

"In all edemas an important thing to bear in mind is the maintenance of an equilibrium between the arteriovenous and the lymphatic circulation. To test the effect of venous congestion on lymph drainage Kollein made a very important contribution in the early seventies. He introduced a cannula into the thoracic duct and noticed that the lymph came out by drops. He then ligated all the veins of the extremities and found that it came out very much better; where a drop came before a cubic centimeter was now collected. In looking this up I found a very important statement made by a famous surgeon by the name of Stromeyer, a surgeon of the Siberian army in the middle of the last century. In his textbook he states his belief that, in cases of elephantiasis of the leg due to filariasis, it would be advisable to ligate the artery.

"Now to return to the treatment by the Kondoléon operation. It has become quite popular. Many cases are on record. Kondoléon has made two publications, the last one two or three years ago. I am indebted to Dr. Royster for references to this paper in the *Münchener medicinische Wochenschrift* for 1915. Dr. Royster was the first one in this country to do the Kondoléon operation. His report is published in the *Journal of the American Medical Association*, 1914. The result of the operation was successful for a time, but the condition returned after seven years. Kondoléon in his second paper, in 1915, made a comment that in cases which had existed for a very long time, the results very probably would not be so good. He described in the first paper the condition of the fascia and aponeurosis. In this paper of Royster's the idea was expressed that, if you took out a long strip of the fascia lata and then closed the skin over it, there is brought about an anastomosis between the deep and superficial lymph spaces. Dr. Sistrunk, of the Mayo Clinic, in *Surgery, Gynecology and Obstetrics*, in 1918, gave a picture of the procedure. In Sistrunk's report the fascia is stripped off, and one gets the impression from the way the stitches are placed that he has tried to draw the fascia together, but this is hardly conceivable.

"In reference to the congenital form there is another interesting condition which we call Milroy's Disease. You all know about it; but it is not Milroy's disease at all. It was well known before. Nonne in *Virchow's Archives*, in 1891, called attention to the familial type, tracing it through several generations. Nevertheless, it is known as Milroy's disease, and we shall never get rid of that name. Milroy thought that filariasis was responsible for the edema, but came to the conclusion, after much persuasion, that a streptococcus infection or some sort of an infection was necessary to bring about the extreme grade of elephantiasis. In order to determine this point, we should have to

make a pathological investigation of those children who die, it being impossible to make a diagnosis otherwise.

"In the old days, very often after operation for carcinoma of the breast the arm would swell. We thought the cause lay chiefly in the fact that we had to remove so thoroughly the contents of the axilla, but we had observed that when an evident infection of the wound occurred the swelling was apt to be more pronounced. We devised the operation which we have done for so many years chiefly to prevent restriction in the movements of the arm, but, later, we were much interested to find that for some reason or other there occurred much fewer swellings of the arm. As I say, the operation was not done to prevent swelling of the arm; it was done to give it a freer excursion, but we found that swelling of the arm was practically eliminated by it (refers to pictures). Instead of drawing skin flaps together after this operation, we actually push them apart so that we have a great amount of redundant skin in the axilla. We also have redundant skin here in the lower flaps. The Thiersch skin-grafting is done at the time of the operation. We could present many pictures showing the perfect result after this operation, but the main point I want to make here is that it stopped the swelling. We are inclined to think the reason is that the dead space, treated by the old method, filled with blood and serum that often developed an infection which was not recognized, but which was enough to account for the slight induration below the clavicle so familiar to every surgeon. Inasmuch as at present all our tissues are made redundant and sutured without any tension, we practically never get any marginal necrosis, which always means a certain amount of infection. I do not believe that excision of the veins has much to do with the swelling, for we have had a number of cases in which veins have been excised and no edema has resulted. I told you of one case in the clinic two weeks ago. It was in the patient who had had frequent attacks of swelling of the arm. Then there was that very interesting case of the woman operated on three years ago for breast carcinoma and who had had no swelling of the arm. Recently, she had influenza and after it she developed constitutional symptoms during which her hand became swollen like a boxing-glove and pitted on pressure. We will take that observation up some time again. Certainly, in our experience, excision of the lymphatics does not produce a swelling, nor does excision of the vein, *without the presence of an infection.*"

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A Case of Reverdin Skin Grafting Exhibited in Dr. Halsted's Clinic on Wound Healing

By Max Brödel

DOCTOR HALSTED saw with the eyes of a real artist the beauties of the healing process as it progressed in this wound, which had resulted from the amputation of a foul sloughing breast cancer that had bled until the patient was almost exsanguinated. He thought it so instructive that he requested me to make this permanent record of it. The Reverdin grafts had been applied by Dr. Mont R. Reid in three groups, at intervals of ten days, so that the different stages of the growth of the epithelium can be followed.

The area of the youngest grafts is nearest the axilla; the oldest near the sternum. The most recent grafts are about ten days old. Each graft stands out clearly as a semi-transparent patch of skin with a pigmented central spot. From these grafts a thin film of superficial non-pigmented epidermis has spread over the whole granulating area, producing a milky appearance, as compared with the fiery red color of a fresh granulating wound.

The middle patch is ten days older. The pinch grafts show the central pigment more clearly. They have flattened out and grown somewhat larger. The epidermic film has become thicker. It is devoid of pigment and presents a homogeneous pinkish appearance, suggesting the skin of a white person. Some of the grafts did not take, but the gaps have been bridged over completely by the pink epidermis. Around each graft a wreath of delicate vessels can be demonstrated, with branches converging toward the pigmented center. The new formation of pigment follows this vigorous new circulation, and the pigmented center is seen spreading in star-shaped fashion toward the vascular wreath.

The right patch near the sternum is the oldest. It was planted ten days before the middle patch. Here the grafts have again increased in size, partly at the expense of the intervening areas of newly formed pink epidermis. It is clear, however, that the narrowing of the pink area is due chiefly to wound contraction. The capillary wreaths have become more clearly defined, and the rich blood supply has evidently stimulated the formation of new pigment cells in the pinch grafts. The color of the pigment in these mature grafts is considerably darker than the skin of the patient's thigh, from which they were taken. On the other hand, as stated above, there is a uniform shrinkage of the entire area, the brown, as well as the pink portion, which may in part account for the massing of the epithelial cells and consequent darkening of the color, a phenomenon similar to the formation of a linea nigra on the abdomen of a negress after childbirth.

REVERDIN SKIN GRAFTING AND WOUND HEALING

UNIV. OF WISC.

Certain Types of Congenital Heart Disease Interpreted as Intracardiac Arteriovenous and Venoarterial Fistulae[1]

I. Patent Ductus Arteriosus

By Emile Holman

From the Department of Surgery, Western Reserve Medical School, Cleveland

In A discussion before the National Academy of Sciences[2] in March, 1919, Dr. Halsted called attention to the similarity between arteriovenous fistula and patent ductus arteriosus in the following statement:

> Our experimental and clinical observations on arteriovenous fistula and partial occlusion of large arteries may ultimately aid in the explanation of the sequelae of certain congenital anomalies of the heart and aorta. May we not regard the persistent ductus arteriosus as an arteriovenous fistula, the pulmonary artery and the right heart representing the venous side of the fistula? The enlargement of the left heart we might assume to be analogous to the dilation of the artery proximal to a fistula; and in the dilation of the right heart and pulmonary artery we recall the dilation of the veins.

Under Dr. Halsted's supervision much valuable information was subsequently obtained by abstracting the comparatively few descriptions of patent ductus arteriosus recorded in the literature. An analysis of these descriptions affords a striking confirmation of Dr. Halsted's prediction that the explanation for the circulatory changes in arteriovenous fistula would, when found, be applicable also in cases of patent ductus arteriosus, although not precisely in the way he anticipated.

Broadly speaking, we may consider a patent ductus as an intracardiac arteriovenous fistula, since its effects may be limited, as will be demonstrated, to one-half of the heart, depending upon the direction which the flow of blood takes in its passage through the ductus.

Definite experimental evidence[3] is available to show that the enlargement of the heart and proximal vessels in a peripheral arteriovenous fistula is dependent on the increased

[1] Read before the Clinical Society of Surgery, October 18, 1924.

[2] Congenital Arteriovenous and Lymphatico-venous Fistulae. W. S. Halsted, *Proc. Nat. Acad. Sci.*, v, pp. 76–79, March, 1919.

[3] Experimental Studies in Arteriovenous Fistula. By Emile Holman: I. Blood volume changes. II. Pulse and blood pressure changes. (With A. C. Kolls.) III. Cardiac dilatation and blood vessel changes. *Arch. Surg.*, November, 1924, ix, 822–879.

volume of blood which flows through that part of the circulatory system proximal to the abnormal communication. This increased volume is intimately dependent in turn on the size of the fistula,[4] as demonstrated both clinically and experimentally. In the presence of a large permanent fistulous opening between the common femoral or common iliac vessels, the volume of blood traversing the heart per unit of time was actually doubled.[5] The increased propulsive effort necessary to advance this larger volume of blood should, theoretically, result in hypertrophy of the heart muscle, and experimentally such hypertrophy has been definitely established. Additional experimental evidence was obtained to show that *by dilatation* the heart and blood vessels will place themselves in harmony with the amount of blood traversing them. Blood vessels which had dilated proximal to an arteriovenous fistula showed complete regression to normal after its excision. Hearts which had enlarged following the establishment of an arteriovenous fistula again diminished in size after its repair. This dilatation was also ascribed to the larger volume of blood flowing through that part of the circulatory system proximal to the fistula, including the heart.

These experimental results prompted the statement, as a theoretical possibility, that the most effective physiological stimulus to which the heart will respond by hypertrophy is an increased flow through its chambers per unit of time. Each organ or tissue in the body has its own "physiological" stimulus. A bolus of food causes peristaltic waves in the esophagus and in the intestine. The special senses have their own specific physiological stimuli. The striped muscle receives its impulse through the nerves. Similarly, we may ascribe to the flow of blood through the heart a physiological stimulus which evokes in the healthy cardiac muscle a contraction in order to advance the blood contained in the heart chambers, just as food in the alimentary canal provokes peristalsis. As a result of an increase in the flow through the heart per unit of time, the number of contractions will be increased and the cardiac effort augmented. Kulbs[6] has produced a 50 per cent increase in the size of the heart in young dogs by increasing the cardiac effort resulting from the exercise of constant running.

Unexpected evidence in favor of the view that the heart and blood vessels will place themselves in harmony with the volume flow of blood through them, both by dilatation and hypertrophy, is presented by a study of the highly variable effects which are associated with such congenital anomalies as a patent ductus arteriosus, a patent foramen ovale, or a defective interventricular septum.

In looking over the autopsy reports of the recorded cases of patent ductus arteriosus, the many different

[4] Arteriovenous Aneurysm: Clinical evidence correlating size of fistula with demonstrable circulatory changes. By Emile Holman. *Annals of Surgery*, Dec., 1924, lxxx, 801–816.

[5] Experimental studies in arteriovenous fistula, IV. Cardiac Output. By Harrison, Dock, and Holman. *Heart* (in press).

[6] Kulbs, *Arch. f. exp. Path. u. Pharm.*, 1906, lv, 288.

descriptions of the heart seem at first glance to be wholly irreconcilable. In certain instances a preponderate hypertrophy of the left side of the heart is recorded. In others, the right side was found enormously enlarged. For the purpose of this study only those cases are considered in which the patent ductus is uncomplicated by, and unassociated with, other lesions.

Few attempts have been made to explain these very diverse findings. The accepted explanation for the rightsided hypertrophy is dependent on a raised arterial pressure in the pulmonary artery subsequent to its direct communication with the aorta. To the same degree—so it is stated—to which the pressure in the pulmonary artery is increased, must the right ventricle become hypertrophied in order to advance the blood against this raised pressure. Further—so it is said—the overfilling of the arteries of the lungs prevents complete emptying of the right ventricle; there occurs, therefore, a dilatation of this ventricle which extends backwards to the right auricle and to the veins of the body.

Other writers present the clinical findings without attempting to explain them. Maude Abbott, in Osler's *Modern Medicine*, says:

> In a patent ductus with otherwise normal conditions, the blood stream will be directed chiefly from the aorta, where the blood pressure is higher, into the pulmonary artery. This is evidenced by the funnel-shaped form with its base toward the aorta, which the canal usually assumes in adults, and by the presence of mycotic vegetations on the adjacent wall of the pulmonary artery in all the cases of acute infective endarteritis in the neighborhood of a patent duct. . . . . Dilatation of the pulmonary artery, and hypertrophy and dilatation of the right ventricle are the usual results of patency of long standing. *Rauchfuss thought them characteristic of all cases, but exceptions occur.* The left ventricle may share in the hypertrophy and the aorta be moderately dilated. In Fagge's case, a woman aged forty-two, the right ventricle was greatly hypertrophied, being equal to the left in thickness; the right auricle was dilated, and the main pulmonary branches, especially the right, were much dilated. The left ventricle is occasionally hypertrophied in excess of the right. In rare instances, as in Walsham's and Drasche's cases, aged respectively forty-seven and twenty-nine years, the heart may not be hypertrophied at all.

Rokitansky[7] asserts that the direction of the flow through the ductus is from the aorta to the pulmonary artery, presenting as evidence the dilatation of the right heart. He further says he found no instance in which the ductus remained open from the pulmonary end following interference with the normal lung development, and his observations lead him to believe that the persistence of the duct is determined from the aortic end.

A close examination of the clinical material indicates that the various findings are in complete accord with the mechanical effect of shortcircuiting a volume of blood through the patent ductus arteriosus, the effect upon the heart of such an abnormal communication depending, first, on the direction of the flow of blood through it, and second, on the volume of blood flowing through the opening per unit of time. The

[7] Uber einige der wichtigsten Krankheiten der Arterien. Karl Rokitansky, Wien, 1852.

latter is obviously dependent on the size of the opening.

The introduction of a peripheral arteriovenous fistula establishes two systems of circulating blood, but as there is only one direction in which the blood may flow through the abnormal opening, the subsequent

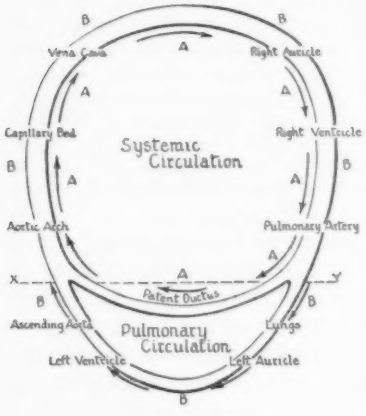

FIG. 1. Scheme of circulation in the presence of a patent ductus arteriosus acting as a venoarterial fistula transmitting venous blood from the pulmonary artery to aorta: Type I. The stream of blood passing through the systemic circulation and right heart is larger than that flowing through the pulmonary circulation and left heart.

effects upon the heart and blood vessels are fairly constant, depending, primarily, on the amount of blood flowing through the fistula back to the heart. The blood shortcircuited through the fistula passes through both sides of the heart, and if the deflected stream be large enough, a dilatation and hypertrophy of both sides inevitably follow. Similarly, the introduction of a patent ductus into the circulation also provides a shorter route for a portion of the circulating blood, with a faster "turnover" by the central pump and meter, the heart. Unlike the peripheral fistula, however, only half of the heart is involved in propelling forward the stream of blood deflected through a patent ductus. The blood stream through the abnormal communication may flow either (1) from pulmonary artery to aorta, or (2) from aorta to pulmonary artery. The first condition (Type 1, Fig. 1) prevails during intrauterine life. Division of the current occurs in the pulmonary artery and only a portion of the stream passes through the lungs, while the larger stream passes through the capillary bed of the rest of the body. If this route through the patent ductus persists after intrauterine life, certain inevitable results would be expected, provided the size of the opening is sufficiently large to permit a considerable diversion of blood from its normal route through the lungs. The amount of blood flowing through circuit A, above the line joining x and y, will be greater than that flowing through circuit B, below the line xy by the amount passing through the patent ductus.

Theoretically, therefore, if we consider the blood-flow to be the most effective physiological stimulus to cardiac hypertrophy and dilatation, the part of the heart which develops in excess of the other should be that through which the larger stream is passing, namely, the part above the line xy, which includes the right heart, the pulmonary artery, and the *aorta beyond the patent ductus*

(Fig. 1). Clinically, a number of cases may be cited which show a dilated right auricle, a hypertrophied right ventricle, a widely dilated pulmonary artery, and in some instances a demonstrable dilatation of the aorta just distal to the opening into it of the patent ductus. The following cases are illustrative of this condition:

Case 1. S. O. Wasastjerna: Finska läkaresällskapets handl., 1874, xvi, 4, 235. Reviewed in Schmidt's Jahrbücher, Leipzig, 1876, clxix, 142.

Female, aged 13. Heart enlarged. In the left second intercostal space, one heard a weak blowing, long-drawn-out murmur with slight systolic reinforcement, which, however, was distinctly heard at the close of the diastole. The pulse seemed to be normal in rhythm and frequency. No signs of disturbance of venous circulation were present. During the subsequent course there was heard at the apex, and daily growing stronger, the systolic murmur above-mentioned, which finally smothered the first heart sound. The rapidly increasing heart insufficiency with cyanosis of the face, cough, dyspnea, and anxiety, without objective signs in the lungs, pointed to endocarditis. The patient died suddenly. *Autopsy:* Lungs livid, bloodless, acutely emphysematous; liver and spleen enlarged and full of blood, but of normal consistence. Heart markedly hypertrophied on both sides, especially on the right where the musculature was larger than on the left. Valves normal; nowhere any signs of acute endocarditis. The ductus botalli was open, its lumen almost round, diameter 1.2 to 1.3 cm. The edges at the origin from the aorta were sharp, those at the pulmonary artery were rounded. The latter opening appeared to be more fusiform. Circumference of aorta: at the origin, 5 cm.; shortly before the ductus, 3.5 cm.; at the ductus itself, 4 cm.; higher up, only 3 cm.; and still higher, 3.3 cm. Circumference of pulmonary artery at origin, 6.5 cm. (Fig. 2).

Case 2. P. Duroziez: Mémoire sur la persistance du canal artériel sans autre communication anormale. Gaz. méd. de Paris, 1863, (année 34), s. 3, xviii, 451.

Male, aged 40, dated his illness from 1855 when he attempted to lift a bag of coal. In January, 1856, the limbs began to swell and became blue. For the two months preceding the examination the oppression had increased, the limbs had become as "hard as wood," and he had had intense headache at night. Occasional slight epistaxis occurred. Examination: Pulse variable. Heart sounds sharp, the second sound loud.

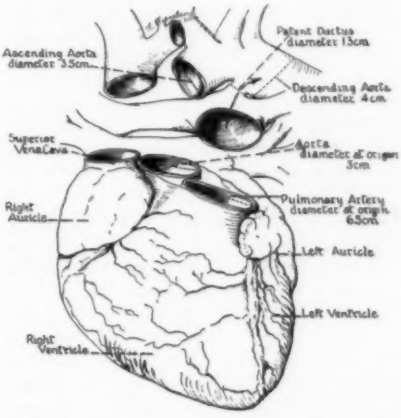

FIG. 2. Reproduction of post-mortem findings in Case 1, exhibiting the typical development of the heart accompanying a patent ductus of Type I: right heart enlarged, origin of pulmonary artery greater than that of the aorta, descending aorta enlarged distal to patent ductus.

There were no murmurs. The apex beat was in the fifth space. Dullness more extensive than normal. A little ascites present. On the 18th of February, the pulse was small, hands cold, and face purple; pulse 96, irregular. On the 19th of February, the pulse was 120, very small, and irregular. Death from asphyxia. *Autopsy:* Heart large, round, plump, with little fat, the musculature strong. Right auricle dilated. The apex of the heart was formed by the greatly hypertrophied right

ventricle; a little atrophy of the left ventricle; the left auricle about normal. Thickness of the walls of the right ventricle at the thickest part, 20 mm. (normal 6 mm.); muscular columns strong, large. Greatest thickness of left ventricle, 10 mm. (normal 15 to 16 mm.); capacity of this ventricle one half that of the right ventricle; muscular columns atrophied; bicuspid and tricuspid of same thickness. Capacity of the left auricle about the same as that of the left ventricle; right auricle a little smaller than the right ventricle. Circumference of the pulmonary artery above the valves, 80 mm. At a distance of 50 to 60 mm. from the superior edge of the sigmoids, the ductus botalli opened by an orifice about the size of a large pea. This orifice was hard, ossified. Circumference of the aorta above the sigmoids, 55 mm.; before the origin of the ductus botalli it measured only 45 mm.; circumference of descending portion, 50 mm. No valvular defects present.

Case 3. Dr. P. Duroziez: Mémoire sur la persistance du canal artériel sans autre communication anormale. Comptes rendus des séances et mémoires de la Soc. de biologie, Paris, 1862, s. 3, iv, 285.

Infant, aged 2 months, first seen on account of cyanosis. The patient died one month later. *Autopsy* showed persistent ductus arteriosus, valve of the foramen ovale partly open, right ventricle hypertrophied, and pulmonary artery a little dilated.

Case 4. Luys: Persistance du canal artériel chez une femme agée, sans communication à travers la paroi soit interauriculaire, soit interventriculaire, du coeur. Comptes rendus des séances et mémoires de la Société de biologie, Paris, 1856, s. 2, ii, 74.

The patient entered the infirmary complaining of a progressive difficulty in respiration from which she had suffered for six weeks. She said that she had suffered from childhood from dyspnea and suffocation on violent exertion; notwithstanding this, her general health had been good. Examination showed edema of the lower extremities, skin and lips bluish, tendency to chilliness. No abnormal heart bruit was made out; beats were slow, dull, and deep; radial pulse scarcely felt and venous pulse on both sides of neck very marked. Death from edema and cyanosis. *Autopsy:* Right ventricle hypertrophied; its walls were firm, rigid, did not collapse, and measured 1 cm. and 1.5 cm. in thickness. The muscular columns were considerably thickened and robust. The semilunar valves were normal. The pulmonary artery, opened along its length, presented three superimposed orifices, separated from each other by two folds in the form of spurs. The lower orifice was the right pulmonary trunk. The central orifice was the left pulmonary trunk. Finally, the upper orifice was nothing less than a point of communication with the arch of the aorta. The orifice easily admitted the end of the ring finger. The walls of the left ventricle were flabby and soft, and measured only 60 to 70 mm. in thickness. The valves were normal. The right auricle was much dilated, with muscular fibres enlarged and thick. The color of the internal surface was a very vivid red, and was of the same aspect as the normal left auricle. The left auricle had, on the contrary, a membranous appearance, its cavity was pale and whitish in color, and was small in comparison to the other. The right and left auriculoventricular orifices were normal. Lungs normal; liver, spleen, and kidneys greatly congested.

Case 5. Johann Schnitzler: Klinische Beobachtungen uber Persistenz des Ductus Arteriosus Botalli. Zeit. der k. Gesellschaft der Aertze in Wien (Medizinische Jahrbücher), Wien, 1864, Jahrg., xx, Bd. 1, 128.

Female, aged 43, said she had been healthy up to 18 months before, when her feet suddenly began to swell. She complained of difficulty in breathing and palpitation of the heart. The thorax was narrow with considerable arching of the cardiac region. Abdomen not swollen, the lower extremities edematous. Fingers knobby. Especially striking was the unusually high degree of cyanosis. Apex beat in the mammary line between the fifth and sixth ribs. At this point, as well as over the entire heart region, a thrill was felt. Auscultation over the left ventricle revealed a

long-drawn blowing murmur. In the right ventricle the sounds were clear. The aortic sounds were strikingly dull and were muffled by a murmur on account of increased heart action. Over the pulmonary artery was heard the systolic murmur above mentioned. Liver and spleen somewhat enlarged. The pulse was very small, accelerated, 108–120. Respirations 42–48. The patient complained of palpitation of the heart, shortness of breath, and a feeling of cold, especially in the extremities. The symptoms increased in severity and erysipelas developed. Death from exhaustion. *Autopsy:* In the pericardium there was 1 ounce of reddish serum. The walls of both ventricles were light red-brown and firm, especially on the right. Right ventricle 7 mm. thick, the left ventricle 5 mm. thick. Both arterial trunks were conspicuous for their size; both, especially the pulmonary artery, were covered with fibrous, bony plaques. Between the two, at the situation of the ductus arteriosus, there was a vessel equalling in thickness that of the pulmonary artery. The aortic opening was 6 mm. in diameter, the opening into the pulmonary artery was 5 mm. in diameter.

Case 6. Arnold Josefson: Offenstehender Ductus Botalli nebst Atherom in den Ästen der Arteria pulmonalis. Nordiskt medicinskt Arkiv., Stockholm, 1897, n. s. vii, p. 1, no. 10.

Female, aged 66, had noticed palpitation of the heart and shortness of breath on exertion for a year. Examination: Insignificant edema of limbs and trunk. Pulse uniform, full, 72. Heart impulse strongly felt in the sixth intercostal space, somewhat outside the mammary line. A diastolic thrill was plainly felt in the fourth left intercostal space. At the apex, and especially distinct to the left of the sternum in the mammary plane, a diastolic murmur was heard. The second pulmonic sound was not distinctly stronger, perhaps because it was smothered by the same murmur, which was also heard here. No venous pulse. Radial arteries somewhat tense. Lungs normal. Liver dullness in the right mammary line extended 3 to 4 cm. below the edge of the thorax. The patient died suddenly. *Autopsy:* The heart was somewhat larger than the fist of the body. The apex was formed mostly by the right ventricle. The tricuspid valve admitted four fingers. The wall of the right ventricle was hypertrophied, measuring 7 x 6 x 4 mm. Right auricle markedly dilated. Valves of the pulmonary artery markedly thickened. The mitral valve admitted two fingers. The wall of the left ventricle was somewhat thicker than usual. Nothing of interest in the aortic valves. No septum defect; foramen ovale closed. The heart muscle in the right ventricle felt firm; in the left ventricle the consistency was somewhat doughy. Close above the bifurcation of the pulmonary artery was a communication between this artery and the aorta. The communication consisted of a canal widening towards the aorta. The pulmonic mouth of the canal consisted of a sharply defined round opening 4 mm. in diameter; the aortic opening was elliptical, 10 x 6 mm. in diameter. The aorta, at its exit from the heart, measured 7 cm. in circumference. The pulmonary artery, which throughout appeared to be enormously dilated, measured at this same level 8.5 cm. in diameter.

Case 7. Kate Campbell Mead: Persistent patency of the ductus arteriosus. Degeneration of the cardiac muscle and coronary arteries, and of the sino-auricular bundle, followed by rupture of the right ventricle. *Jour. Am. Med. Assn.* 1910, lv, 2205.

Female, aged 26. Dr. Thayer, of Baltimore, wrote: "There is evidently a congenital malformation, but one which, from her history and condition, may well be compatible with a long life. There is a loud machinery murmur over the right ventricle with systolic accentuation, which together with the accentuation of the second pulmonic sound, and the rather large right side, suggests a septum defect. A striking feature of this case is the fact that the murmur continues throughout both cycles of the heart with the heart sounds heard, as it were, superimposed." *Autopsy:* Heart: Pericardial sac contained about 2 ounces of fluid blood. There were three ruptures of the right ventricle parallel to the descending branch of the anterior coronary artery. The ductus arteriosus

was patent, the opening into the aorta was 1 cm., and into the pulmonary artery 4 mm. in diameter. It was funnel-shaped, with the large end in the aorta, and 1 cm. in length. The aortic opening of the duct was located opposite the left subclavian artery. The heart weighed 395 grams. The right side was dilated and hypertrophied, containing fluid blood. The right auricle and ventricle were nearly twice as large as normal, and the right ventricle was nearly as thick as the left, which was also hypertrophied. The foramen ovale was closed. The pulmonary artery was almost twice the size of the aorta. The aortic opening was stenosed, cusps thickened.

Case 8. G. A. Gibson: Clinical lectures on circulatory affections. Lecture 1. Persistence of the arterial duct and its diagnosis. *Edinb. Med. Jour.*, 1900, viii, 1.

Female, aged 31. The patient was a thin sallow woman. There was no clubbing of the fingers, and her lips had a very faint bluish color. . . . . The patient complained of pain in the region of the praecordia. She had always been subject to palpitation on exertion or excitement. Diffuse pulsation was visible all over the praecordia. At the base of the heart an almost continuous rushing murmur was heard, beginning shortly after the first sound, which was quite clear at its commencement, and continued almost to the beginning of the next sound. . . . The second sound was heard distinctly in the middle of this murmur; it was distinctly accentuated, and sometimes doubled. Pulse 72, respirations 24. The patient died of pneumonia. *Autopsy:* The pulmonary artery was enormously distended with blood; on separating it from the aorta, and tracing the pulmonary artery to its bifurcation, the left branch was found to be united to the surface of the aortic arch just beyond the left subclavian artery by a very short ductus arteriosus. The duct was patent, and the opening admitted a 12 to 14 bougie. There was no patency of the foramen ovale, and no opening in the interventricular septum. The mitral and tricuspid orifices were healthy, although the latter was considerably dilated. The left ventricle was normal as regards thickness of wall and length of cavity. The right ventricle was dilated and hypertrophied, the wall measuring $\frac{3}{16}$ inch in thickness.

Case 9. Ketil Motzfeldt: Drei Fälle von offenstehendem Ductus Arteriosus Botalli. *Deutsche med. Wchnschr*, 1913, Jahrg. xxxix, 2037.

Male, aged 32, said that he had had a defective heart since his second or third year. For two weeks he had coughed a good deal, with bloody expectoration. Before his present illness he had not had a cough or night sweats. The patient was thin, pale and weak. Pulse 112, regular, weak. Respirations 28, deep. First sound over the entire heart not clear. There was a short, presystolic secondary sound, and at the apex a suggestion of doubling of the second sound. Death with increasing dyspnea and cyanosis. *Autopsy:* When the thorax was opened considerable hypertrophy of the heart was evident. This extended to both ventricles, but was more marked in the right, which was remarkably well developed and alone formed the apex. The right ventricle had a very strong trabecular and papillary musculature, and the thickness of the wall varied from 5 to 10 mm. The endocardium of the left ventricle was symmetrically thickened and of a gray color; the thickness of the musculature reached from 8 to 10 mm. All valves were sufficient and of the usual appearance. The foramen ovale was closed and there was no septum defect. The pulmonary artery, which was greatly dilated and markedly larger than the aorta, measured 10.5 cm. in circumference, 1 cm. above the valves. One centimeter above the valves the aorta measured 7.4 cm. Quite high up on the descending aorta, in the part near the arch, was a round opening, 8 mm. in diameter. This opening, corresponding to the site of the ductus arteriosus, led as a broad connecting passage directly into the pulmonary arteries.

Case 10. Ketil Motzfeldt: Drei Fälle von offenstehendem Ductus Arteriosus Botalli. *Deutsche med. Wchnschr.*, 1913, Jahrg. xxxix, 2039.

Female, aged 55. For the past two years the patient had shown symptoms of

heart trouble. She was very cyanotic, with marked edema. . . . . Pulse 90. Apical impulse in the fifth intercostal space in the mammary line. A weak systolic murmur was heard, with maximum intensity over the apex. *Autopsy:* The heart was markedly enlarged from hypertrophy and dilatation of the right side. The apex was formed by both ventricles. Weight 700 gm. The papillary and trabecular muscles in the right ventricle were much more strongly developed than in the normal heart. The pulmonary artery with its branches was markedly dilated; here there was marked arteriosclerosis. In the pulmonary artery, just on the inside of its bifurcation, was a small indented point to which a loose red-brown thrombus was attached. This part was intimately connected with the aorta, and from the aortic side was seen a funnel-form hollow which led into the opening in the pulmonary artery.

Case 11. Hermann von Schrötter: Ueber eine seltene Ursache einseitiger Recurrenslähmung, zugleich ein Beitrag zur Symptomatologie und Diagnose des offenen Ductus Botalli. *Ztschr. f. klin. Med.*, Berlin: 1901, xliii, 160.

Female, aged 15, complained of marked shortness of breath and palpitation of the heart. According to the mother, the patient's face had been blue-colored from birth. Lately marked oedema of the legs had appeared. Examination revealed a cyanosis of the face, the mucous membranes livid, undulation of the veins, but no positive venous pulse. Apex beat in fifth intercostal space, two fingerbreadths outside of the mammary line, where a distinct thrill was felt. Auscultation at the apex showed a loud presystolic-systolic murmur and a dull second sound, frequently followed by a short diastolic murmur. The systolic murmur became more intense above, reaching its maximum over the epiphysis of the fourth rib in the third intercostal space to the left of the sternum. Besides this, one perceived distinctly a sort of rumbling diastolic murmur. Over the pulmonary artery the murmurs were less distinctly heard (the second pulmonic sound was markedly accentuated). They were not transmitted to the large vessels. Pulse 100–120, regular, in no way characteristic. Examination of larynx showed the left vocal cord completely immovable, approximated to the midline, but no changes were made out on the right. Voice clear, nothing striking about it. *Autopsy:* Heart enlarged. Cavity of the left ventricle and its musculature showed no changes. Cavity of the right ventricle and right auricle much dilated. Musculature of right ventricle thickened, very resistant, bright brown. The root of pulmonary artery broader than that of the aorta, circumference 7.5 cm. as against 5 cm. Ductus botalli patent, as large as the branches of the pulmonary artery; circumference 3.5 cm. Illustration shows constriction of aorta proximal to entrance of ductus.

Case 12. James Foulis: On a case of patent ductus arteriosus, with aneurism of the pulmonary artery. *Edinburgh Med. Jour.* 1885, xxx, 17.

Female, aged 22, complained of great palpitation of the heart on slight exertion, and buzzing noises in the chest, the head and in the ears. Nose and lips pale with a slightly bluish tinge. On placing the stethoscope over the base of the heart there was heard a loud blowing systolic murmur with a decided thrill, and at the same time a strong heaving impulse accompanied the heart's systole. Immediately following the systolic murmur another softer murmur was heard. The point of maximum intensity of both murmurs was to the left of the sternum between the second and third ribs. Death from exhaustion. *Autopsy:* The heart as a whole was much enlarged. There was evident hypertrophy of both ventricles, the left wall measuring ¾ inch in thickness, and the right wall ¾ inch in thickness. The ventricular cavities were both considerably dilated. The left auricle was only slightly, the right auricle considerably, the conus arteriosus very much, dilated. At the bifurcation of the pulmonary artery the ductus arteriosus was patent, the orifice being large enough to admit freely a goose quill. When viewed externally its narrowest diameter appeared to be about ¼ inch. The pulmonary artery,

as a whole, was found to be dilated to at least twice its natural size, and the primary divisions of the pulmonary artery were both of large size, the right being at least nearly twice as large as usual. The circumference of the pulmonary orifice at the level of its cusps was 3½ inches. The orifice of the aorta was about natural in size. Both pulmonary and aortic valves showed vegetations attached to the corpora arantii. The wall of the aorta at the point of junction with the ductus arteriosus was distended somewhat in a funnel-like manner. The lumen of the ductus arteriosus was partly plugged by a protruding offshoot of the coagulum from the pulmonary artery. On the posterior wall of the aorta, *exactly opposit* there *orifice of the patent ductus arteriosus,e the* was a rounded bulging or lens-shaped concavity in the aortic wall, which measured one inch in diameter, and in depth about a half an inch.

Case 13. Dr. Heinrich Hochhaus: Beiträge zur Pathologie des Herzens. 1. Ueber das Offenbleiben des Ductus Botalli. *Deutsches Arch. f. klin. Med.*, Leipzig, 1893. li. 1.

Male, aged 24, entered the Kiel Surgical Clinic to be treated for frostbite. On arising one morning he complained of pains in the praecordia and palpitation of the heart. The patient had been well up to the twelfth year, after which he frequently had had pains in the cardiac region. Apex beat in the fifth intercostal space, near mammary line; heaving. Relative heart dullness 5 cm. to the right, 12 cm. to the left. On auscultation at the apex, there was a systolic bruit. Over the aorta, the first sound was loud; the second also distinct but ending in a bruit; over the pulmonary artery, the first and second sounds were clear and loud. There was also a long-drawn-out whistling bruit which was heard only in diastole, peculiarly roaring and audible in its greatest intensity in the second intercostal space exactly over the pulmonary artery. Pulse regular, of small volume, both sides equal, 86 to 90 a minute. Temperature 38 to 38.4°C. *Diagnosis:* Endocarditis and persistent ductus botalli. Heart action became frequent and arhythmic, with hemorrhages over the whole body, and increasing weakness of the heart. *Autopsy:* Right ventricle drawn decidedly forward. Heart musculature very hypertrophic—1 cm. thick at origin of pulmonary artery, 1.5 cm. at the ventricular septum, 1.6 cm. in the left ventricle. Origin of the pulmonary artery greatly dilated. On the anterior wall of the pulmonary artery, 1.5 cm. above the valves, were found numerous growths. These vegetations covered the wall for a width of 6 mm. and reached without interruption to a cleft-formed opening 7 mm. wide, corresponding to the situation of the ductus botalli. . . . . This led through a short canal about 6 mm. wide to the aorta. Towards the aorta, the canal assumed a funnel shape, 1.4 cm. wide. *At the point opposite to the dilated ductus botalli the wall of the aorta close between the origin of the intercostal arteries was covered with elevated inflamed growths.* The aorta in the neighborhood of the ductus botalli lay in numerous longitudinal folds, otherwise, the wall was smooth and soft. Just above the valves the aorta was 6 cm. wide, at the isthmus, 5 cm., somewhat below the origin of the ductus botalli, 6 cm.

Case 14. W. H. Simmons: Congenital heart malformations. *Intercolonial Med. J. of Australia*, Melbourne, 1906, xi, 65.

Female, aged 16 months. The mother stated that she had always noticed that the baby's heart pulsated forcibly, and that its lips and fingers, though usually pale, became bluish on crying. On examination, the heart's apex was found to be in the fifth intercostal space, just in the nipple line. There was marked cardiac pulsation, and part of the heart could be felt two finger-breadths below the left costal margin. The whole of the praecordial region of the chest was markedly bulging. On auscultation, a loud systolic murmur was audible all over the chest, being of maximum intensity at the left nipple. At the pulmonary area there was a blowing systolic murmur, but the second sound was clear. Cardiac dullness extended from the right parasternal line to the left nipple line. Death from pneumonia. *Autopsy:* A very large, patent ductus arteriosus was found. There was no valvular lesion. The right border of

the right ventricle was the part of the heart palpable below the costal margin.

Case 15. J. Darier: Persistance du canal artériel chez une femme de 51 ans. *Bull. Société anat. de Paris*, 1885, (Année lx) s. 4, x, 55. (Séance du 30 janvier, 1885).

Female, aged 51. The patient said that she had suffered with palpitation ever since she could remember. She lived a normal life, and the palpitation was produced only by violent or long-continued effort, and was not accompanied by marked suffocation. For two months her strength had failed, the palpitation had become worse and she had noticed swelling of the limbs at night. The patient presented a cachectic appearance. She was very pale. The lower limbs were edematous up to the thigh. There was no marked dyspnea, but there was a cough and slight bloody expectoration. Pulse unequal and irregular. The heart was plainly hypertrophied, and at each systole lifted up slightly the thoracic wall. On auscultation one found over the whole precordial region a soft and prolonged systolic murmur. This murmur had two foci of maximum intensity, one near the apex, without propagation to the axilla, and the other at the level of the aortic orifice. From this last point the murmur could be followed by means of the stethoscope into the carotids, and even as far as the left axillary artery. Throughout it was synchronous with the ventricular systole, and kept its soft timbre. A double lesion of mitral insufficiency and of aortic constriction appeared to be the only explanation of the peculiar distribution of this morbid sign. The liver was painful on pressure and was enormous, reaching beyond the false ribs by 12 cm. Fifteen days later, the emaciation and cachectic state had increased. The icterus grew progressively, the very large liver showed pulsations; the limbs remained swollen; the dark urine contained albumin. Pulse rather strong, but unequal and, above all, irregular. Death from pneumonia. *Autopsy:* The heart was of enormous size and had a rather marked fatty surplus. Its apex was bilobed and formed concurrently by the two ventricles. The orifice of the pulmonary artery was perfectly sufficient. But what struck one at the first view was the plainly exaggerated size of the pulmonary artery, the walls of which were, however, not altered. The circumference of this artery, measured at the level of the valves, was a little above 14 cm. The same measurement applied to the aorta and at the same level gave only 10 cm. There was on the concave side of the arch an orifice which made a communication between the cavity of the aorta and the left branch of the pulmonary artery, that is to say, a persistence of the arterial canal. This orifice, which would admit a pencil, was almost circular. No other abnormalities. The liver was voluminous, greatly congested, and a little sclerosed.

Case 16. C. V. Weller: Coarctation of the aorta with patent ductus arteriosus. *Intern. Assn. of Med. Museums*, Bull. No. VI, August, 1916, p. 115–117.

Male, 12 days old. Apparently a normal child until the ninth day, when a marked cyanosis and a loud systolic murmur rapidly developed, followed by death on the twelfth day. *Autopsy:* Heart twice the normal size. Apex formed by the greatly hypertrophied right ventricle. Lungs showed marked congestion and edema. Spleen and liver large, firm, markedly congested. Microscopic sections showed marked changes of the nutmeg-liver type. The right ventricle formed three-fourths of the total bulk of the heart, its wall 7 to 8 mm. in thickness. Left ventricular wall only 4 to 5 mm. in thickness. As it emerged from the heart, the aorta measured 7 mm. in diameter. This trunk gave off an innominate artery, 6 mm. in diameter, which appeared to be a direct continuation of the aorta, while bending sharply to the left a smaller vessel, less than 5 mm. in diameter, represented the aortic arch. Beyond the point of origin of the left subclavian there was a portion of the aortic arch 5 mm. in length and 4 mm. in diameter. This entered the arterial trunk, made up of the pulmonary artery, the ductus arteriosus and the descending aorta, sharply at right-angles. The pulmonary artery was 1 cm. in diameter as it left the heart. The ductus arteriosus measured 6 mm. in diameter.

In reviewing these sixteen descriptions of patent ductus, one's attention is immediately arrested by the similarity of development to which each case conforms. A dilated right auricle and an hypertrophied right ventricle were invariably noted, the right ventricle being in most instances equal to, or greater

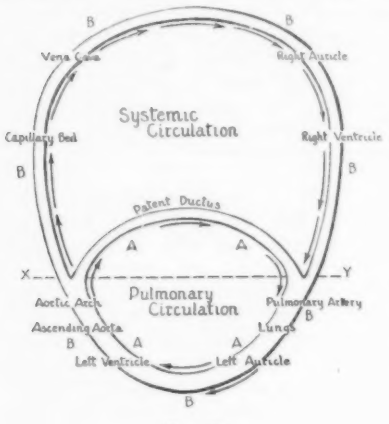

FIG. 3. Schema of circulation in the presence of an uncomplicated patent ductus acting as an arteriovenous fistula transmitting oxygenated blood from the aorta to the pulmonary artery: Type II. A larger stream of blood is flowing through the pulmonary circulation than through the systemic circulation.

than, the left ventricle, in the thickness of its wall and the size of its cavity. The pulmonary artery in each case measured considerably more than the aorta as they emerged from the heart. In Cases 1, 2, 11, 13, 16, there was described a dilatation of the aorta beyond the entrance of the patent ductus. In Cases 12, 13, 16, we find positive unequivocal evidence that the flow of blood occurred from the pulmonary artery to the aorta. Since the development in these three instances corresponds accurately with that found in the other cases, all of which showed a preponderance of the right heart, we may assume that the flow of blood in all of them occurred from pulmonary artery to aorta, thus resulting in a deflection of blood directly from the venous to the arterial side of the circulation. Under these circumstances, it would be more accurate to designate the patent ductus as a "venoarterial" fistula and not as an "arteriovenous" fistula.

The development of the right heart, commensurate with the volume flow through its chambers, is illustrated in a striking manner by Case 16. It may be argued that this greater volume flow indicates that the right heart is supplying a greater area of distantly located capillary bed than the left heart is called upon to supply, and is, therefore, overcoming a greater peripheral resistance than the left heart. The two factors are necessarily very intimately associated, but from the point of view of *both* dilatation and hypertrophy the more important factor is the greater volume flow through the right heart per unit of time.

In a second group of cases the division of the current occurs in the aorta; a part of the stream passes through the patent ductus into the pulmonary artery, thence through the lungs, the left heart, and the aorta again (Fig. 3). Under these conditions the systemic circulation receives less blood than the pulmonary circulation. The stream of blood passing through the circulatory system below the line *xy* will be augmented by

the blood flowing through the ductus, and will be greater in volume than the stream through the system *B*, above the line *xy*, by the amount thus deflected through the ductus.

Theoretically, therefore, that part of the system below the line *xy* (Fig. 3), through which the greater stream passes, would undergo a greater development than is normally true. Clinically, cases are encountered exhibiting a dilated left auricle, a hypertrophied left ventricle, but with a small right ventricle. The following cases illustrate this type quite accurately.

Case 17. H. D. Gaylor: Patent ductus arteriosus and saccular aneurysm of the aorta. *Trans. Chicago Path. Soc.*, 1918, x, 296.

Mrs. C. was first seen in the summer of 1895 by Dr. Babcock. Her death occurred late in the autumn of 1917, twenty-one years after the first observation. When first seen, she complained of disturbance of heart action, together with fear and coldness of the extremities. There was appreciable dyspnea on exertion, but this did not incapacitate her. The first physical examination disclosed slight enlargement of the heart to the left, with a very distinct presystolic thrill at the apex of the heart and a slight roughness of the first sound, scarcely a murmur. There was a marked machinery-like murmur in the left interspace close to the sternum; although the bruit was continuous, it had a *crescendo* and *diminuendo* intensity that did not agree with either systole or diastole. There was a thrill in this region and the two pulmonic sounds were audible. On these findings a diagnosis of patency of the ductus arteriosus was made, together with some slight roughness of the mitral leaflets. As years went on a dullness gradually appeared to the right of the sternum with an increase in the second aortic sound. As this area of dullness increased, the thrill and peculiar bruit at the left of the sternum diminished and finally disappeared, being replaced by a poorly-defined systolic murmur in the pulmonic area. The heart was gradually displaced to the left. *Necropsy:* The apex of the heart was made up entirely of the left ventricle. There was a saccular dilatation of the first part of the aorta, 10.5 x 8 x 7.5 cm. in its greatest outside dimensions. The right, back, and front walls of the first part of the aorta were markedly thinned out to form the sac. The left wall of the first portion of the aorta was apparently not involved in the dilatation. There was a spontaneous rupture of the front of the aneurysm of the aorta, parallel to the pulmonary artery. The circumference of the aortic orifice was 9.5 cm., whereas that of the isthmus of the aorta was 7 cm. The left auricle was enlarged. There was practically no fat beneath the epicardium of this auricle, whereas that of the right auricle was almost completely covered with yellow fat. The wall of the left ventricle was from 11 to 24 mm. thick. There were only two aortic leaflets, one on each side. The wall of the right ventricle was from 4 to 8 mm. thick. The pulmonary orifice was 5.3 cm. in circumference. There was a patent ductus arteriosus 10.5 cm. above the base of the pulmonary valve. The aortic end of the ductus arteriosus, just distal to the isthmus, was 6 mm. in diameter. (Microscopically, the wall of the aneurysm of the aorta was made up almost entirely of hyaline connective-tissue fibers, interwoven with a few elastic bundles. In places the wall was abruptly broken across with the production of marked defects. There was a marked infiltration of lymphocytes around the vasa vasorum of the aorta.)

Case 18. Crouzet: Persistance du canal artériel. *Bull. Soc. anat. de Paris*, 1870, 2. s, xiv, 323.

Female, apparent age 16, admitted as an idiot. Slight cough. Very intense cardiac murmur with the first sound; second sound well separated from the murmur, which preceded and followed it. Pulse frequent and full. The patient suddenly became cyanosed and died. *Autopsy:* Heart the size of an adult man. The aorta had a circumference of 43 mm. at its origin. Pulmonary artery, at its origin, 43 mm. in

circumference. The aorta, below the left subclavian, had a circumference of 35 mm. The heart was slightly hypertrophied. Internal circumference of left ventricle at the base 110 mm.; wall 18 mm. thick. Right ventricle smaller and almost filled by the bulging of the septum. The wall of the right ventricle was 7 mm. thick. The pulmonary artery had three branches; two lateral, destined for the lungs, while a third, originating from the origin of the left branch, went to the aorta. This arterial duct was 28 mm. from the heart, and admitted a penhandle 6 mm. in diameter. Its internal circumference was about 19 mm., or about equal to that of the innominate.

Case 19. J. Thomson and W. B. Drummond: Nine cases of Congenital Heart Disease. *Edinburgh Hosp. Repts.*, 1900, vi, 57.

"Mongolian" imbecile aged 3½ years; no cyanosis. A loud, harsh systolic murmur was audible all over the cardiac area. It was loudest over the fourth and fifth left spaces and cartilages near the sternum. There was also a loud, but less harsh, systolic murmur in the pulmonary area and outside it for about one inch. *Autopsy:* Broncho-pneumonia present. The heart was slightly enlarged. The apex was rounded and formed entirely by the left ventricle. The right auricle and appendix were dilated; the foramen ovale was closed. The right ventricular cavity was considerably smaller than the left. Marked thickening of tricuspid valve segments. The interventricular septum was entire. The left auricle was normal. The left ventricular wall was thickened. The ductus arteriosus was widely open (cone diameter ¼ inch). The pulmonary arteries were of large size.

Case 20. Buchwald: Aneurysma des Stammes der Arteria pulmonalis. *Deutsche med. Wchnschr.*, Berlin, 1878, iv, I, 13, 25.

Female, aged 21. Pulse changeable, 92–128. Pain in the left thorax; a loud bruit extending into diastole, and a blowing sound over the pulmonary artery. Weak systolic sounds over the remaining heart openings and carotids. Heart hypertrophy on the left. *Autopsy:* The pulmonary artery was large, and the irregularly swollen wall was thickened. The left ventricle in the centre was 1.7 cm. thick. Size of the left ventricle and left auricle decidedly increased. At the beginning of the descending aorta was a sharp ledge in the intima, at the anterior edge of which there was a crater-like opening in the vessel wall. The trunk of the pulmonary artery, just before the left branch, was reached through this opening in the aorta, which admitted a thick catheter. Right heart scarcely dilated; wall in the centre of the conus arteriosus 3 mm. thick; in the centre of the ventricular cavity 4 mm. thick.

Case 21. S. L. Wasastjerna: *Finska läkaresällskapets handl.*, 1874, xvi, 4, 235. Reviewed in *Schmidt's Jahrbücher*, Leipzig, 1876, clxix, 142.

Male, aged 36, was subject to palpitation of the heart and dyspnoea on exertion. These attacks came on at intervals of several months, lasted several hours with extraordinary acceleration of the pulse, which could not be accurately counted, but which was as rapid as 200 per minute. At the same time there appeared orthopnea and bloody expectoration. In the intervals the cardiac action was irregular; radial pulse full and strong. Heart enlarged in length and breadth, cardiac impulse strong and disseminated. Over the whole cardiac area there was heard a systolic roaring murmur, strongest at the upper left part of the sternum. Death from typhoid fever. *Autopsy:* The right ventricle somewhat hypertrophied; the left ventricle much hypertrophied. All valves normal. No defect in the interventricular septum. The ductus botalli was open and its lumen as large as a thick pencil, with a fusiform exit from the aorta, which was *insignificantly narrowed at this point.*

Case 22. Montague Murray: Patent ductus arteriosus in a woman, aged 36, dying of malignant endocarditis. *Tr. Path. Soc.*, Lond., 1888, xxix, 67.

Female, aged 36. Delicate all her life, but never cyanosed. On admission, the heart was found to be hypertrophied and

dilated. There was a systolic thrill over the pulmonary cartilage, and a loud, harsh, grazing systolic murmur to be heard all over the cardiac area. Some of those who examined her maintained that a faint diastolic thrill and murmur could occasionally be made out over the pulmonary cartilage. The patient wasted rapidly and died. There had been neither cyanosis nor clubbing of finger ends. *Autopsy:* Right auricle normal. Left ventricle: lining membrane roughened. The pulmonary artery communicated with the aorta by means of a passage ½ inch long. The passage was in shape that of a short truncated cone, with base towards the aorta. It just admitted an ordinary quill. Heart hypertrophy general, but most marked on left side.

Case 23. George Carpenter: Congenital morbus cordis. *Proc. Roy. Soc.*, 1908–1909, ii, 163.

Female, 3 months old. Typical mongol. There was a loud systolic murmur, best heard over the third left interspace conducted towards left clavicle. No thrill. No cyanosis. *Autopsy:* Left side of heart much larger than right, which was dwarfed. Left ventricle formed the whole of the end of the heart. Right ventricle appeared to occupy about half of the area of the left, and to extend only half way down the ventricular portion of the heart on its own side. The walls of the right ventricle were on the thin side, as those on the left were on the thick side. The left auricle was twice the size of the right, which was small. Tricuspid and mitral valves normal. The foramen ovale was closed. The pulmonary valve had three cusps, the aortic, two cusps. The pulmonary artery had three branches, right, left, and the ductus arteriosus, which was only a little smaller than the aorta. At the point of union with the ductus there was a decided, though small, constriction of the aorta (Fig. 4).

Case 24. C. Gerhardt: Persistenz des Ductus arteriosus Botalli. *Jenaische Zeitschrift für Med. u. Naturwissenschaft*, Leipzig, 1867, iii, 105.

Female, aged 3. The patient had from infancy shown a somewhat bluish color of the skin, became easily out of breath with running, and tired easily. There was no edema, but the mother had noticed a striking beating of the arteries. Slight cyanosis and "chicken-breast"; apex beat strong in the sixth intercostal space; strong pulsation of the right ventricle at the epigastrium. Suggestion of a systolic bruit at the apex, strong and scraping at the ends of the second and third intercostal space. Pulse of the crural arteries distinct. In November, 1864, the child was again brought to the hospital with scarlet fever, and died. *Autopsy:* Heart about four time as large as the fist. Apex of the heart

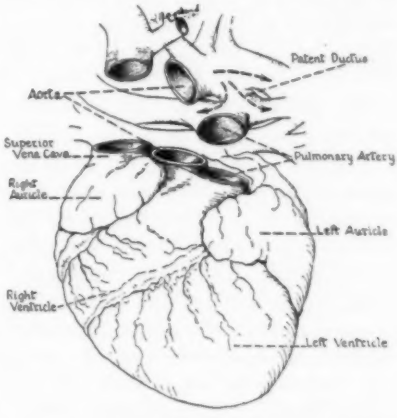

FIG. 4. Reproduction of post-mortem findings in Case 23, showing the response to the greater stream flowing through the left heart and the pulmonary circulation: dilated left auricle, hypertrophied left ventricle, narrowing of descending aorta at site of ductus.

formed overwhelmingly by the left ventricle, the cavity of which was very broad, wall 1.5 cm. thick, papillary muscles thick, all valves normal. Right ventricle smaller. Foramen ovale closed. Aorta and pulmonary artery at their origin each 5 cm. broad, the aorta at the innominate 3.75 cm. broad, beyond the ductus arteriosus 3.5 cm., at the thoracic aorta 3 cm. The circumference and length of the ductus botalli were apparently about equal, the circumference being 2 cm. The width of the canal was everywhere equal and admitted a thin scalpel handle.

Case 25. Hayashi: Stauungslunge bei Offenbleiben des Ductus Botalli. *Monatsch. für Kinderheilk.*, 1912, xi, 224–229.

Female, aged 10½ months; very pale, with pasty appearance; systolic thrill; loud systolic, soft diastolic murmur; pulse regular, strong; edema; no cyanosis. *Autopsy:* Excessive hypertrophy of left ventricle. Dilated right ventricle and dilated auricles. Pulmonary artery and aorta of usual diameter. Ductus botalli 5 mm. in diameter. No septal or valvular defects. The walls of the vessels of the lungs and bronchi show a marked connective-tissue thickening as compared to normal; alveolar walls 2–3 times thicker than normal, the difference due to long duration of *stasis* (?)

The above cases of patent ductus belonging to Type II again present a striking uniformity of development. The left ventricle was invariably greatly hypertrophied in excess of the right, which was uniformly small. The aorta was greater than, or equal to, the pulmonary artery in diameter, with occasional evidence of constriction of the aorta just beyond the emergence of the patent ductus (Cases 21, 23). There was in one instance (Case 17) an aneurysmal swelling of the aorta attributed to syphilis, but which may simply have been due to the gradual thinning of its wall by dilatation in response to the increased flow through it. In spite of the lessened resistance of the pulmonary circulation to the passage of blood, we have in this group an excessive hypertrophy of the left side of the heart. This over-development of the left heart may, therefore, be attributed almost solely to the increased propulsive effort necessary to advance the greater stream of blood flowing through it, as compared with the flow through the right heart. Case 23 is of particular interest in illustrating this effect. The connective-tissue thickening of the vessels of the lungs and bronchi in Case 25 is attributable to an increased flow through the pulmonary circulation rather than to the *stasis* cited by the author.

In the studies of arteriovenous fistula it was found that the demonstrable circulatory changes occurred only in the presence of large fistulae, and that a number of clinical cases were recorded in which the small fistula was unaccompanied by any demonstrable enlargement or dilatation of the heart and proximal vessels. The same is true of the changes accompanying a persistent ductus. There may be no enlargement of the heart, as the following cases illustrate:

Case 26. W. Hale White: Patent ductus arteriosus. *Trans. Path. Soc.*, Lond., 1885, xxxvi, 182.

The patient, aged 53, was admitted for vertigo and pain in the chest. A loud systolic murmur was heard over the left intercostal space close to its junction with the sternum. The pain in the chest was persistent, with occasional exacerbations of the character of angina pectoris, in which he was slightly cyanosed. He was at all times relieved by the horizontal position. He died following a paroxysm of an hour's duration. *Autopsy:* The heart itself was rather small, but perfectly normal in all respects; there was no hypertrophy of the right ventricle. The fluid which was injected into the arteries had passed from the aorta through the patent ductus arteriosus, which was about the size of an anterior tibial artery, to the pulmonary artery, which was thus completely injected.

Case 27. Drasche: Ueber einen Fall von Persistenz des Ductus Arteriosus Botalli: *Wien klin. Wchnschr.*, 1898, xi, 1195.

Female, aged 29. Over the second and third intercostal spaces a systolic thrill

was palpable. Apex beat in the fifth intercostal space somewhat heaving and suppressed with difficulty. Over the apex there was a systolic murmur extending into diastole. Pulse 82. Tension of the radial somewhat above normal. *Autopsy:* Heart small, flabby, thin-walled. Ductus botalli admitted a 3 mm. thick probe through a circular opening between the two vessel trunks which touched at this point.

Case 28. W. J. Walsham: Unobliterated ductus arterilosus without other malformation of the heart and great vessels, from a man, aged 47. *Tr. Path. Soc.*, Lond, 1877, xxviii, 43.

The patient, who was supposed to have pericarditis, died a few hours after his admission into the workhouse. No notes of his symptoms could be obtained. *Autopsy:* The body was well nourished and not cyanotic. No pericarditis or other disease besides the consolidation of the lungs could be discovered. The first point of interest referred to was the existence of the open duct, without any other malformation of the heart or vessels. The unobliterated duct was ½ inch long, and joined the aorta 1 inch below the origin of the subclavian artery. At its aortic end it was ¼ inch in diameter, but it was contracted to the size of a No. 4 catheter, where it sprang from the pulmonary artery. The heart was healthy, and the foramen ovale closed; no contraction of the aortic and pulmonary orifices, or of the aorta, where it was joined by the duct, existed. Both lungs were consolidated at their bases.

In an article based on clinical observations alone, without post-mortem examination, Wessler and Bass[8] make the following statements:

As regards the size of the hearts, only one case showed enlargement to the right, and one case showed enlargement to the left. The shape of the heart, as revealed by the orthodiagraph, is also of importance. Three of the five cases are of normal shape. Of the two others, one has evidence of left ventricle hypertrophy and dilatation; the other shows an enlargement to the right and a rounded shape, characteristic of right-sided enlargement. Examination of Figure 7 shows a dilated pulsating ascending aorta, with hypertrophy and dilatation of the left ventricle. This is the characteristic appearance found in stenosis of the aortic isthmus, a lesion commonly associated with patent ductus arteriosus, and aortic insufficiency has probably developed. The other case in which there is a variation from the normal configuration is shown in Figure 2. In this case an associated congenital lesion has been suspected, owing to the marked clubbing and cyanosis it presented.

From the study of our orthodiagrams, it appears that in pure patent ductus arteriosus one need not expect enlargement of the heart or alteration of its shape, and that the presence of these changes suggests an associated or complicating lesion.

Groedel, who has studied a series of cases with the orthodiagraph, summarizes his findings as follows: "(1) Of all the congenital affections the persistence of the ductus arteriosus Botalli affords the most typical Roentgen picture. The most evident symptoms are the distention and pulsation of the pulmonary artery and the enlargement of the right ventricle by which a round heart is formed. (2) The heart may be normal in size or enlarged, depending on the presence of associated lesions. (3) The murmur may be systolic-diastolic."

In the light of the conception here presented, we may assume that all five cases reported by Wessler represented a "pure patent ductus" without associated lesion, and that the size of the opening was small in three cases and large in the other two. In one of the two latter the flow occurred from pulmonary artery to the aorta with right-sided hypertrophy; in the other the blood passed

[8] Persistent Ductus Botalli and its Diagnosis by the Orthodiagraph. By Harry Wessler, M.D., and Murray H. Bass, M.D. *Amer. Jour. Med. Sci.*, April, 1913, p. 543–555.

from the aorta to the pulmonary artery, resulting in a left-sided preponderance. The absence of demonstrable cardiac changes in the other three cases is dependent on the small amount of blood deflected through the ductus. The lesion may be quite sterile in its demonstrable effects upon the circulatory system, the important factors being—first, the amount of blood shortcircuited through the abnormal communication, and, second, the direction of the flow through the ductus.

The question of cyanosis in congenital cardiac lesions has always been a baffling one. Maude Abbott[9] observes:

> The immediate causation of cyanosis has long been the subject of debate. It has been variously ascribed to (*a*) venous stasis, (*b*) admixture of currents, (*c*) deficient aeration. . . . . Pulmonary obstruction alone appears capable of producing cyanosis, but it is still a question as to which of the above factors is the essential one. The theory that cyanosis is due to a mingling of venous with arteral blood has been sharply and successfully refuted by many authorities. In many instances of biloculate or triloculate heart there is a complete absence of cyanosis.

In the presence of a well functioning heart muscle there is probably only one cause for cyanosis and that is an admixture of currents, but it must be an admixture of currents sending venous blood through the systemic circulation. In Type I the lungs are shortcircuited by the blood flowing through the ductus. If the ductus is large and a considerable amount of blood is deflected, we may expect cyanosis from the deflected unaerated blood. Clinically, the cases showing cyanosis fall into this group. In twelve of the sixteen cases described above, cyanosis was marked; in the other four it was not mentioned. In Type II the systemic circulation is shortcircuited, and as the greater stream is passing through the lungs for constant aeration, we should not expect cyanosis, and, clinically, it is rarely seen except as a terminal event. In seven of the nine cases described as belonging to Type II cyanosis was absent. Theoretically, if the amount of blood deflected from the systemic circulation is large, we should expect a pale ashen color to the skin, and, clinically, such a pallor is frequently described as characteristic of the condition. Cyanosis may be said to be characteristic only in those cases in which the ductus acts as a venoarterial fistula.

A rather startling discovery was made in connection with the mental retardation and idiocy occasionally associated with these congenital lesions. Among the eight patients with patent ductus in whose cases the evidence indicated that the blood flowed through the opening from aorta to pulmonary artery, there were three who were markedly below normal mentality. In this type (II) the peripheral system is shortcircuited, and defective mental development may be ascribed to deficient aeration and nutrition of the central nervous system. Among the sixteen cases in which the evidence indicates that the flow of blood occurred as in the fetus, from pulmonary artery to aorta, there was recorded not a single case of idiocy or mental retardation.

[9] Modern Medicine. Osler and McCrae, Lea and Febiger, 1915.

SUMMARY

Patent ductus arteriosus may be considered as an arteriovenous or a venoarterial fistula, resulting in an abnormal routing of a part of the circulating blood.

Theoretically, the flow through the ductus may proceed from pulmonary artery into aorta, or from aorta into pulmonary artery. In the first instance the lungs and left heart are avoided by the short-circuited blood, as in the fetal circulation. In the second instance, the right heart and systemic circulation receive less blood than the left heart and the pulmonary circulation.

In the first type a larger volume of blood flows through the right heart than through the left heart. From a physiological point of view, this half of the heart should develop more fully than the left, this development being a response to the increased flow of blood through this part of the heart. This increased flow requires increased effort, and hypertrophy will inevitably result if the increased flow is large and if it is permanently maintained. In the second type the larger volume of blood flows through the left heart, and hypertrophy and dilatation would be expected to be limited to this half.

Twenty-eight cases of patent ductus were studied from abstracts made by Dr. Halsted, with the above conception as the basis for our classification. The cases studied were uncomplicated by other congenital anomalies, such as a patent foramen ovale, defective interventricular septum, pulmonary stenosis, atresia of the aorta, or valvular defects. The changes found may, therefore, be ascribed solely to the presence of the patent ductus.

In sixteen cases the evidence indicates that the flow occurred from pulmonary artery to aorta, and these cases are classified as Type I. In this group, the right heart showed an abnormal development, in most instances equal to, and in several cases in excess of, the left heart. A dilated tricuspid ring, a dilated pulmonary artery, and a dilated aorta *beyond* the entrance of the patent ductus, were recorded as characteristic of this group. The sizes of the patent ductus in these cases were as follows:

Case 1. Diameter 1.2 to 1.3 cm.
Case 2. "Size of large pea."
Case 3. Size not mentioned.
Case 4. "Admits end of ring finger."
Case 5. 5 mm. in diameter.
Case 6. 4 mm. in diameter.
Case 7. 4 mm. in diameter.
Case 8. "Admits 12–14 bougie."
Case 9. 8 mm. in diameter.
Case 10. Size not mentioned.
Case 11. "3.5 cm. in circumference."
Case 12. "Admits a goose quill."
Case 13. 6 mm. wide.
Case 14. "Very large."
Case 15. "Admits a pencil."
Case 16. 6 mm. in diameter.

In nine cases the evidence indicates that the flow of blood occurred from aorta to pulmonary artery, and these are classified as Type II. These cases showed a preponderate hypertrophy of the left heart with a dilated aorta to the point where the ductus was given off. The sizes of the patent ductus were recorded as follows:

Case 17. 6 mm. in diameter.
Case 18. 6 mm. in diameter.
Case 19. ¼ inch in diameter.
Case 20. "Admits a thick catheter."
Case 21. "As large as a thick pencil."
Case 22. "Admits an ordinary quill."
Case 23. "A little smaller than the aorta."
Case 24. 2 cm. in circumference.
Case 25. 5 mm. in diameter.

Three cases are also cited in which there were no cardiac changes. Their absence may be attributed to the narrowness of the canal which permitted only a small volume of blood to be deflected through the opening. The sizes of these fistulae were described as follows:

Case 25. "Size of anterior tibial artery."
Case 26. 3 mm. in diameter.
Case 27. "No. 4 catheter."

The evidence furnished by these clinical observations indicates that the heart and large vessels will accommodate themselves to an increased flow through them, both by dilatation and by hypertrophy, the hypertrophy of the heart being a response to the increased effort necessary to advance an increased flow through its chambers per unit of time. The degree of hypertrophy and dilatation, we may assume, is commensurate with the volume of increased flow, and is limited to that half of the heart through which the greater flow passes, the right side undergoing a greater development than the left when the blood flows from pulmonary artery into aorta, and the left heart developing more than the right when the blood flows from aorta to pulmonary artery.

Those cases in which a well marked cyanosis was exhibited in their clinical course fell into Group I. In this type the ductus acts as a venoarterial fistula, the lungs are shortcircuited and a considerable quantity of blood escapes into the systemic circulation without aeration. Cyanosis is the logical result. Most of the cases without cyanosis fell into Group II. In this group the systemic circulation is avoided by a part of the circulating blood, but the entire volume of each cardiac cycle is subjected to aeration. No cyanosis would be expected, and it but rarely occurs except as a terminal event.

The three cases of idiocy associated with this congenital cardiac defect fell into Group II, in which, so it is assumed, there is an interference with the proper development of the brain, probably through malnutrition, which may be explained by the deflection of the main stream of circulating blood from the systemic to the pulmonary circuit.

Blind-End Circular Suture of the Intestine
(Halsted Method)

By William Francis Rienhoff, Jr.
Resident Surgeon, Johns Hopkins Hospital

In 1887 Dr. W. S. Halsted (1), in conjunction with Dr. F. P. Mall (2), both of them associated in the Department of Pathology of the Johns Hohns Hopkins Medical School under the direction of Prof. William H. Welch, began working upon the problem of intestinal suture. It is hardly a matter of surprise that a research attacked by their productive minds should have resulted in fundamental contributions in the fields of anatomy, physiology, and surgery.

From 1802, when Bichat (3) in his *Traité des membranes* first called attention to the tendency of serous surfaces to adhere, until 1887, when Dr. Halsted (1) published his epoch-making work, intestinal anastomosis had been the center of a great controversy. Many methods of intestinal suture had been suggested by surgeons of wide experience and international reputation, beginning with Lembert (4) and Jobert (5), in 1826, and including such famous men in the surgical world at that time as Madelung (6), Kocher (7), Reichel (8), Czerny (10), Rydygier (11), and Gussenbauer (12). Although brilliant achievements were occasionally reported, the results of enterorrhaphy were uncertain and the mortality was very high, even in the hands of the most skilful surgeons. The operation was imperfect, and the dicta of prominent surgeons were accepted by many without due thought and consideration. The controversies engaged in prior to 1887 were to a great extent over the relative merits of several different types of sutures; but in the end, regardless of the method employed, the results were equally uncertain, and the principles of intestinal suture were in a state of confusion. Dr. Halsted, in writing of the methods, says:

> I have no doubt that the results of these operators were much better than I could have obtained by their methods as they describe them; for each, with his great experience must have acquired an art of sewing which from a scientific standpoint was not sufficiently precise to be communicated to others.

In this basic work of 1887 Dr. Halsted laid down the fundamental principles of intestinal suture, when he for the first time demonstrated the surgical importance of the submucous coat of the intestine. The insistence of Jobert and Lembert in 1826 on the apposition of serous surfaces in intestinal suture had led to the development of the so-called peritoneal and sero-muscular sutures, which were based on an incorrect conception of the anatomical struc-

ture of the intestinal wall. It was definitely shown at this time by Dr. Halsted that intestinal sutures which did not include the submucosa were dangerous. The difficulties attending the tearing out of such sutures were entirely obviated by engaging the tough submucous coat in the stitches. Experimental results at that time and since have confirmed this original contribution, which "from a scientific standpoint is sufficiently precise to be communicated to others." At the present time the submucous stitch is considered the *sine qua non* in intestinal suture, and it has made possible the great advances in gastro-intestinal surgery that have taken place in the last thirty-seven years. The importance of this fundamental contribution is obvious and the application universal.

In 1891 Dr. Halsted (13) again emphasized the importance of employing the submucous coat in intestinal suture and urged the adoption of a method of intestinal anastomosis which would cause the minimal degree of soiling, namely, the insertion of quilted or mattress sutures before the lumen of the intestine is opened. This method was suggested for use in lateral anastomosis.

After 1887 not a year passed that Dr. Halsted or one of his assistants did not resume work on intestinal suture. In 1909 Dr. Halsted (14, 15, 16, 17) became especially interested in aseptic end-to-end suture of the colon, and between 1909 and 1922 many different methods of reëstablishing the continuity of the intestinal lumen were employed by him. Notable among these methods was the bulkhead suture of the intestine, which was accomplished by means of several different materials such as paper cones, licorice or fibrin boli. However, it was not until 1922 that an aseptic blind-end circular suture of the intestine was accomplished which Dr. Halsted "deemed worthy to offer to the surgical profession for trial."

A series of 47 dogs were operated upon by this method without a fatality, and all had a normal convalescence. The absence of adhesions about the site of anastomosis in these animals indicated the minimal amount of soiling. A single row of mattress sutures of fine black silk was employed in all anastomoses by this method, the different operators being very careful not to penetrate the lumen of the intestine, as this would undoubtedly open up a source of infection. The technique employed and the illustrations, which clearly explain the method of Dr. Halsted, will be given in the report of the following case of a patient upon whom I operated in June, 1924.

CASE REPORT

L. S., aged forty-six, white, male. Admitted to the hospital June 16, 1924; discharged July 21, 1924. The patient came into the hospital complaining of abdominal cramps, marked constipation, blood in the stools, and a slight loss of weight. He had been perfectly well previous to the onset of the present illness, which was nine months before; at that time, after a rather severe attack of diarrhea lasting about five days, he suffered with obstinate constipation, relieved only by severe purges. He was generally constipated for a period of five months, when he began to have abdominal cramps in the lower portion of the abdomen and some slight distention associated with these cramps. He states that at the end of the cramp-like pain he was aware of a gurgling, squirting sensation in the lower left quadrant. The cramps and the dis-

tention were temporarily relieved by evacuation of the bowels. The patient had noticed from time to time that there had been occasional streaks of red blood in the stools. He had lost a slight amount of weight and had noticed increased susceptibility to fatigue.

normal masses were palpable. The sigmoid colon could be rolled beneath the fingers and seemed somewhat thickened.

The interest in this case centered in the rectal examination. There were a few external hemorrhoids symmetrically arranged. The mucous membrane of the rectum was

FIG. 1.

Examination. The patient was a thin, undernourished man. The general examination was entirely negative, including that of the abdomen. Liver, kidneys, and spleen were not palpable, the percussion note was everywhere tympanitic. No bosses or ab-

everywhere normal in consistence. Prostate and seminal vesicles were normal. At the very tip of the examining finger one could feel a nodular mass which gave the impression that it was not an internal growth but one pressing on the lumen of the

FIG. 2.

rectum from the outside. The mass was freely movable and seemed not to be attached to the portion of the bowel which could be palpated. There was no blood on the examining finger. The temperature was

cells. The urine showed a trace of albumin, 1+. A barium enema showed the rectum very much dilated with a small amount of the opaque enema in the sigmoid; the obstruction was evidently due to a neoplasm.

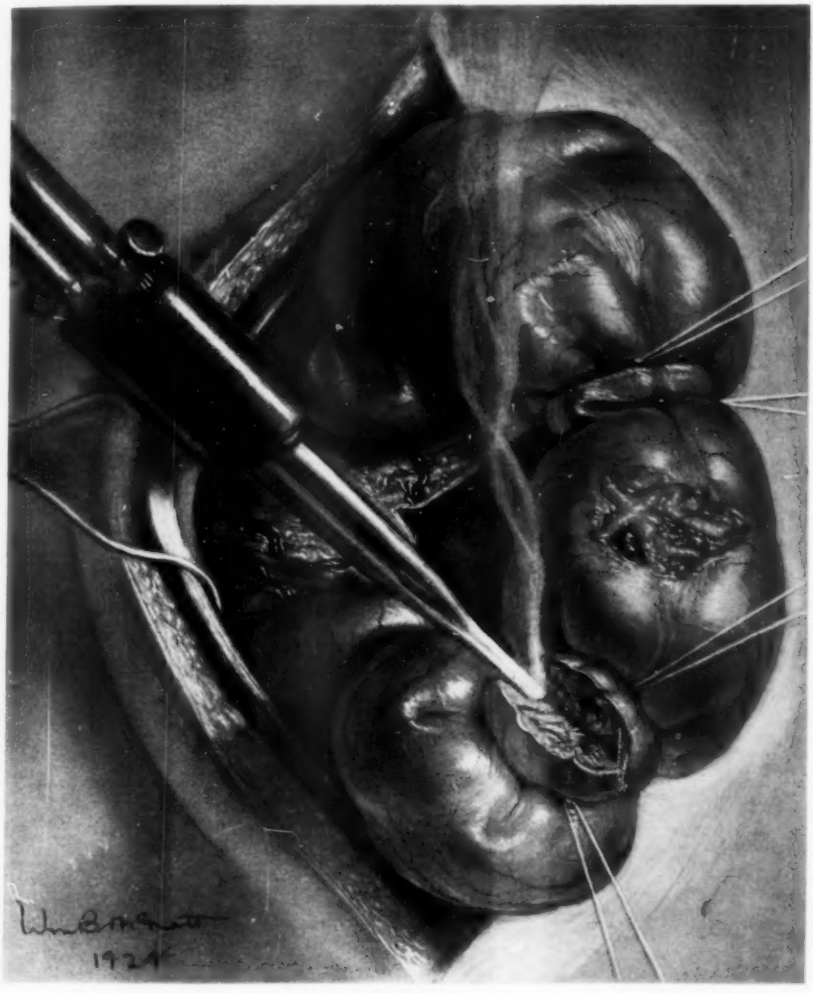

FIG. 3.

100.2°; pulse 110; respirations 24. Hemoglobin 85 per cent. White blood count, 10,500. Wassermann negative. The stool examination for blood was positive. A few red blood cells were seen, also white blood

Diagnosis. Carcinoma of the lower end of the sigmoid.

Operation. June 19, 1924. The exact technique employed in this operation was described in detail in Dr. Halsted's article

on his experimental intestinal suture. The illustrations of this case are taken from the operation at the time of its performance, with the exception of Figures 6, 7, 8 and 9,

made between the umbilicus and the symphysis pubis. The anterior sheath of the rectus was incised and the muscle fibers were split along their course. The perito-

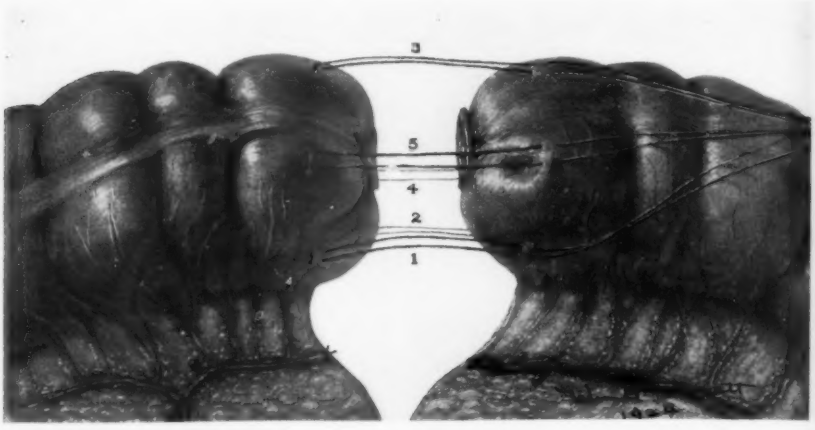

FIG. 4.

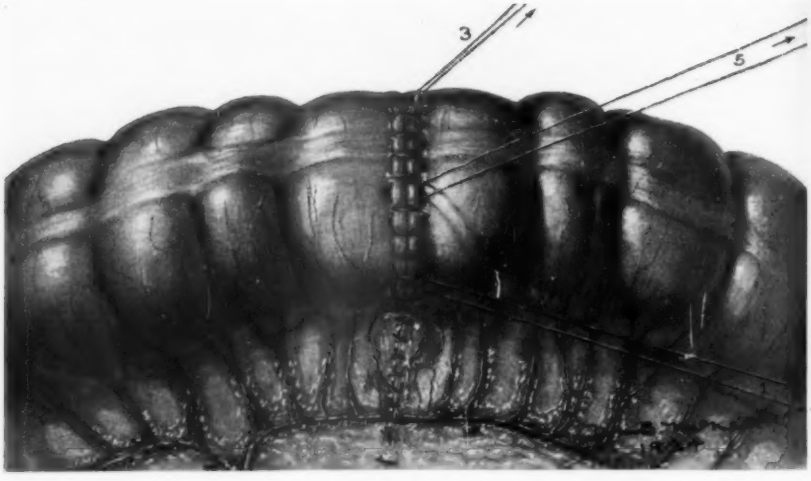

FIG. 5.

which are copied from Dr. Halsted's article. for the convenience of those who are not familiar with this method.

Iodine technique of the skin was employed. A lower left rectus incision was

neal cavity was opened, and an annular carcinoma was discovered at the lower end of the sigmoid colon just above the promontory of the sacrum. The tumor represented (Fig. 1) is not quite as large as the actual

growth. The adjacent bowel was perfectly normal except that the proximal colon was slightly more dilated or greater in diameter than the distal side. There was induration near the growth for an approximate distance of 6 cm. In the mesentery immediately subjacent to the growth there were two palpable, discrete lymph nodes which were quite soft. These were removed; a frozen section revealed no evidence of metastases. The liver was everywhere smooth, and the growth was entirely free, not being adherent to any of the neighboring structures. The colon was mobilized by incising the peritoneum in the region of the growth and, as shown in

FIG. 6.

Figure 1, could be lifted a considerable distance into the abdominal wound. It was immediately seen that, after a resection, the blind ends could be brought together without any tension if an end-to-end anastomosis was made, but that in order to make a lateral anastomosis it would be necessary to mobilize the bowel still further, which would of necessity and because of stretching jeopardize the circulation as well as create quite definite tension. Hence, it was determined to resect the growth and perform the Halsted operation.

The operative field was carefully packed off with Mikulicz pads and warm salt sponges. The vessels of the mesentery directly beneath the growth were doubly ligated with No. 1 plain catgut and cut between the ligatures (Fg. 1). A Kocher

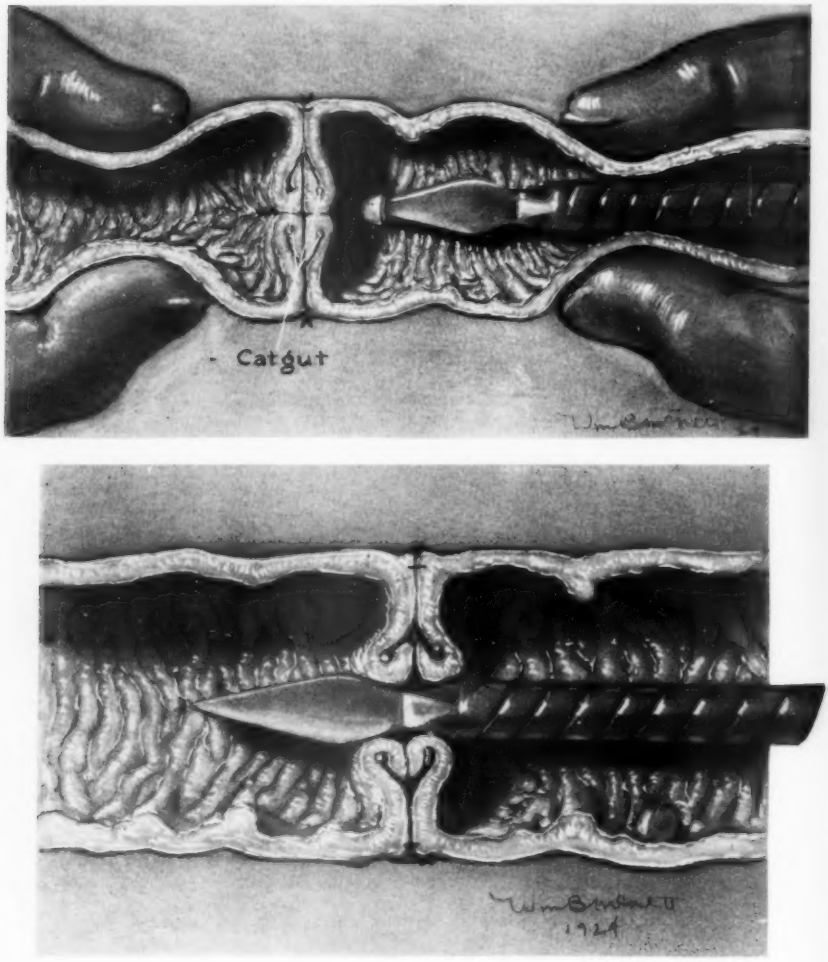

Fig. 7.

clamp was used to mark the bowel 6 cm. above and also below the growth. Along the proximal edge of the mark made by the proximal Kocher clamp and along the distal edge of the mark of the distal clamp four purse-string sutures (Fig. 2) of No. 1 plain catgut were placed and the ligatures tied in one knot so that this could be tightened after the bowel was divided. Clamps were placed on the portion of the bowel to be resected, to serve as handles. Between each pair of purse-string sutures the bowel was divided with a cautery (Fig. 3). The stumps of the bowel were trimmed with scissors as close as possible and the everted bowel teat was again touched with the cautery. The mattress sutures were then placed in the order suggested by Dr. Halsted, the first two on both sides of the mesentery and immediately in the mesentery, which Dr. Halsted had years ago named the Mitchell-Hunner stitch. One other mattress suture was placed in the antemesenteric border and one on each of the lateral borders of the intestine (Fig 4). These sutures were tied, and other mattress sutures were placed about a quarter of a centimeter apart and reinforced by Halsted interrupted sutures (Fig. 5). About sixteen sutures in all were placed. The knife was inserted *per rectum* with the cork tip in place as shown in Figs. 7 and 8. The knife was passed *per rectum* without difficulty to the point of anastomosis and the cork tip was then removed. The knife was passed through the center of the diaphragm, the cutting of the purse-string suture (Fig. 7) being definitely felt. The knife was withdrawn, and a bougie to dilate the diaphragm still further was inserted (Fig. 8). Following this a rectal tube was placed through the opening made by the bougie and allowed to remain in place about 8 cm. above the site of the anastomosis, being fastened to the buttocks with small strips of adhesive. Although there was no soiling, it was thought advisable to anticipate any trouble and two cigarette drains were, therefore, placed in the peritoneal cavity, a little distance from the suture line. The peritoneum was sutured with a continuous suture of double medium silk, and stay sutures of silkworm gut were placed in the wound, the anterior sheath of the rectus muscle was closed with interrupted figure-of-eight sutures of double medium silk, and the skin with interrupted fine silk sutures. The patient left the table in excellent condition.

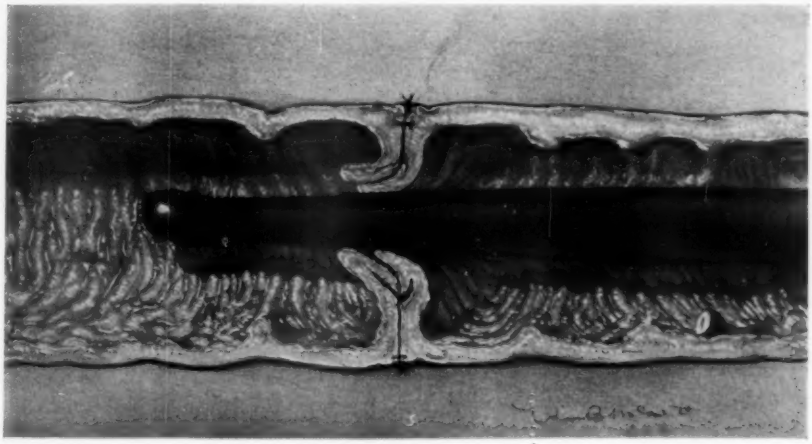

FIG. 8.

Post-operative course. Twelve hours after operation gas and fluid fecal material were passed by way of the tube. The drains were removed in twenty-four hours and

some slight drainage persisted from the tract produced by them for two days. The rectal tube was removed in forty-eight hours. Twenty-four hours after the operation the patient had a fluid stool and thereafter had perfectly normal bowel movements every twenty-four hours. There was not the slightest evidence of distention, nausea, or vomiting. The temperature rose to 100° and 101° on the first and second days after operation, but promptly fell to normal, at which point it remained until

FIG. 9.

the date of discharge from the hospital. The patient's convalescence was almost like that from an interval appendix operation, and he was ready for discharge at the end of fourteen days, but was kept another week to obtain a barium enema roentgenogram.

The barium enema (Fig. 9) showed a return of the lumen of the bowel to a little more than half its normal size, which I took to mean that the inturned bowel wall or flange had flattened out in the process of healing. This flattening had apparently progressed rather rapidly in so short a period as two weeks. The patient was discharged perfectly well and according to recent letters has since been enjoying excellent health.

DISCUSSION

The case reported above was one of fairly early carcinoma of the lower end of the sigmoid colon. It was necessary to perform some type of end-to-end anastomosis because of the fact that it would have been impossible to mobilize the bowel sufficiently to perform a lateral anastomosis without jeopardizing the circulation, in the region of the suture line, because of the tension which would have been necessary to secure proper approximation of the free ends. The various methods of open end-to-end anastomosis of the colon are, as is well known, associated with soiling. This case, then, seemed an ideal one in which to apply the method described by Dr. Halsted, and I believe this to be the first occasion on which this method has been performed successfully on man.*

The method was much quicker than the open method, and there was no soiling whatever of the suture line except the amount that would occur in an interval appendix. The knife per rectum was passed with ease, and no difficulty was experienced in getting an amount of normal intestine distal to the site of anastomosis sufficient to enable me to grasp firmly the shoulder of the knife—a point of great importance for the success of this method. Only one row of medium "C" silk mattress sutures was employed, reinforced by single interrupted Halsted stitches.

I do not believe that the method of cutting the purse-string suture is one of very great importance, as it can be cut equally well with a knife *per rectum*, with a cautery wire sewed in the purse-string, or with any one of many small knives which have been devised since Dr. Halsted published this method. The main advantages, it seems to me, associated with this procedure are as follows:

1. There is practically no soiling, and thus the *formation* of postoperative adhesions is avoided.
2. It is more rapidly executed.
3. It requires less handling of the bowel and no special clamps.
4. It provides ideal peritoneal apposition.
5. The entire amount of bowel remaining after resection, except the amount turned in, can be utilized.

*Since writing this paper I discovered that Dr. Wm. A. Fisher of Baltimore had used this method in 1922 upon a patient suffering with carcinoma of the sigmoid colon. Only two inches of normal bowel remained distal to the anastomosis which made it impossible to control the knife passed per rectum. A colostomy was done and the knife passed through the colostomy opening. The patient made an uneventful recovery. The importance of having enough bowel distal to the anastomosis has been emphasized above.

6. The various methods of invaginating the bowel, as in the bulkhead sutures, are very satisfactory, experimentally, where one has, as in the dog, an abundance of bowel and mesentery; but they cause a waste of entirely too much normal intestine, and thus a marked shortening, to be employed successfully on man.

A rectal tube can be inserted beyond the line of anastomosis and acts as an excellent drainage tube for fecal material and gas, thus obviating the necessity of a colostomy and preventing almost entirely post-operative discomfort and distention.

As I was not then aware that this method had been previously applied to man, I did not feel justified in omitting drains altogether, in spite of the fact that there had been no soiling during the operation. I am convinced, however, that one would be perfectly safe in closing the abdomen tightly, as the rectal tube acts as a safety valve and also as a drain.

The post-operative barium enema showed definitely that the inturned edge of the bowel had flattened out markedly in the short period of fourteen days. This straightening out of the flange is probably in inverse proportion to the amount of soiling.

In *conclusion*, I think it can be stated that aseptic blind-end circular suture of the intestine can be employed in the case of man successfully; but, as in all surgical procedures, it would be poor judgment and worse surgery to attempt to adapt any one method to all conditions. The Halsted method is an excellent one for certain cases such as the one above reported.

I wish to thank Prof. J. M. T. Finney for the opportunity of operating upon this patient and reporting the case.

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Book Reviews

How Our Bodies are Made. By R. M. Wilson. 1923. 246 pp. $1.75. (*Henry Frowde; Hodder & Stoughton, London.*)

In this book we find an excellent and graphic description of bodily functions for youthful students. The language is simple and the development of the subject relating to an explanation of the daily routine of our lives is good. It would, however, be much too elementary for the knowledge demanded of our students in Anatomy and Physiology.

J. B.

Medical Quotations from English Prose. By John H. Lindsey, M.D. 1924. $2.50. (*Richard G. Badger, Boston.*)

Here is a curious book which might well have been entitled Medical Quotations from Samuel Pepys, for the "Diary" furnishes nearly two-thirds of the two hundred and ninety-eight pages of quotations while Mandeville gets but one. This makes the work unbalanced, but perhaps this is a fortunate fault, as the extracts from Pepys are far more interesting than those culled from the other authors, which include Sir John Mandeville, Sir Thomas More, Francis Bacon, Robert Burton, Sir Thomas Browne, Jonathan Swift, George Berkeley and Laurence Sterne. The book is illustrated with portraits of some of the above. Brief biographies of a page or less are included and these could have been extended with benefit.

The choice of quotations has not always been the most happy and quite a number are not medical except by a stretch of the imagination, and others, whilst medical, are trivial and uninteresting. Dr. Lindsey passes by the wealth of medical material in Tristam Shandy and contents himself with an unimportant collection from the Sentimental Journey. Apart from the quotations from the "Diary" the book does not carry much weight. But what a feast Pepys gives us. Had the good doctor confined himself to old Samuel and written an essay to go along with the quotations, he had almost of necessity produced a charming book. He may yet avail himself of the opportunity but it seems to me that he missed a great chance. The picture of the plague in London and Pepys' very natural apprehension on account of it are vividly portrayed in very few words. The naive comments of his own ailments and those of others may lead some medically inclined reader to include the Diary in his bedside library, a choice which will never be regretted. The Wheatley edition is by long odds the best to own and it has recently been issued in three handy volumes. All medical lovers of Pepys will give a vote of thanks to Lindsey for his collection of quotations.

J. R.

The Physiology of Muscular Exercise. By the late F. A. Bainbridge. Second edition revised by G. V. Anrep. $3.75. (*Longmans, Green and Company, 1923.*)

The second edition of this monograph preserves the general character of the work in its original form. The chapter headings, sub-headings and text are entirely unchanged. The results of recent research up to the date of publication are included by an expansion of several sections. This has added ten pages to the volume. This series of monographs on Physiology is too well known to need comment and this edition can be recommended to those interested in the subject.

E. K. M.

Human Physiology. By C. G. Douglas and J. G. Priestley. $3.50. *Oxford University Press, American Branch, New York,* 1924.)

This book of 232 pages gives an account of the practical course in physiology which has been developed by the authors for the Final Honour School of Physiology in Oxford. All of the experiments described

are to be carried out on the students themselves as subjects. The purpose of the volume is to emphasize the importance to students of physiology and medicine of gaining by practical experience an acquaintance with "experimental methods which can be employed successfully with a man as subject, and under conditions which approximate closely to perfect normality."

The authors "do not pretend to cover the whole field of human physiology and have, in fact, deliberately omitted all reference to the physiology of the central nervous system and the sense organs." The introduction consists of a few pages of directions for glass blowing, cleaning mercury and pipettes and might well have been omitted. The book is divided into seven sections dealing with respiration, total respiratory exchange and energy production, the blood, the gases of the blood, the circulation, the kidneys, and the alimentary canal. The sections on respiration, respiratory exchange, and blood gases are based mainly upon the well known researches of J. S. Haldane and the authors in these fields and are decidedly the best. The section on blood includes the counting of red and white cells, haemoglobin estimations, agglutination tests, fragility tests, blood volume determination, and several biochemical methods of blood analysis. The section on circulation contains the experiments usually done in most laboratories on man. The experiments on the kidneys illustrate the changes in the blood responsible for diuresis and the effect of exercise on urinary secretion. The book concludes with a study of the alimentary tract by means of the x-rays and examination of gastric contents. References to the literature bearing on the subjects studied are included.

This manual can be strongly endorsed as emphasizing and illustrating how much can be done in teaching laboratory physiology with the human subject, which appears to the reviewer as highly desirable. It can be recommended to teachers for this purpose and as furnishing a source of numerous instructive experiments. On the other hand, it would not seem to be adapted as a laboratory manual for use in the general course in physiology in medical schools in this country, because many of the experiments are suitable only for a small group of advanced students and because laboratory manuals would seem, in general, to be entirely satisfactory for students only in the author's own laboratory.

E. K. M.